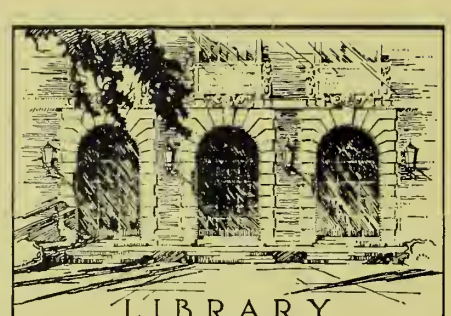

ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION · ENGINEERING PUBLICATIONS VOL. 1, NO. 1, MARCH 1960

A SELF-INTRODUCTION

This is about an organization which annually involves thousands of people and millions of dollars. It is not an industry. It does not manufacture, advertise, or sell a product; it does not strive to earn a profit and the results of its activity benefit everyone. It is the Engineering College of the University of Illinois, and this pamphlet, *Engineering Outlook,* is what we propose to send you to keep you aware of current happenings in the College's program of research, education, and public service.

Engineering Outlook is a new publication of the Engineering College, and this the first issue. It is published by the Office of Publications of the Engineering Experiment Station, the branch of the College which administers the research programs. It will report on various facets of these programs, such as new research facilities and equipment; current inventions and discoveries of widespread interest; and details about research which concern industry, national defense, or the private individual. In addition, information about educational policies, techniques, and facilities that are of public interest will be reported.

Lastly, *Engineering Outlook* will describe current publications of the Engineering College. It will replace the publications "notification" which many of you have received in the past, and will now serve as the sole vehicle for such notification.

Engineering Outlook will be published when there is enough news of interest to our readers to make up an issue, which should approximate one issue every four to six weeks. It will be sent without charge, on request, from the Engineering Publications Office, 114 Civil Engineering Hall, University of Illinois, Urbana, Illinois.

TO KEEP YOU INFORMED

The ultimate product of any research is a report. To be useful, research results must be available for use by others. The results of engineering research at the University of Illinois are available in departmental reports, research monographs, progress reports, graduate theses, etc. This information must be communicated to various agencies, industries, libraries and individual engineers throughout the world. This is the job of the Engineering Publications Office, a part of the Engineering Experiment Station.

Through this office the Experiment Station publishes research material primarily in three series: Bulletins, which record the results of original research; Circulars, which present compilations of facts from literature searches, surveys, or similar sources, and sometimes reports of research results from the smaller research projects; and Reprints, which offer material reprinted from technical journals or industrial publications. Such monographs are available to anyone at a price which approximates the cost of printing, and are listed in an *Index of Publications* available from the Engineering Publications Office.

Until recently, departmental reports and graduate theses have not been listed in such a convenient manner. Now, however, a new booklet entitled *Engineering Departmental Reports and Theses 1958-59* has been published. It lists departmental publications and graduate theses completed during fiscal 1959, and gives abstracts of the departmental reports. It is available free of charge from Engineering Publications. Copies of departmental reports, though printed in limited numbers, may be made available to interested and qualified persons. Abstracts of the dissertations for graduate theses, which are listed in this publication merely by title, can be obtained from the periodical *Dissertation Abstracts.* Microfilms of any graduate theses listed can be ordered from the Engineering Publications Office.

Brief progress reports on engineering research projects still under way can be found in the annual *Summary of Engineering Research.* This Experiment Station publication also lists the names of the project directors, sponsors, and recent publications which have grown out of the project. The issue for 1959 will be listed in this paper when it becomes available in the near future.

OPEN HOUSE FOR ALL

A state university has a duty to tell the people what it is doing in its three fields of activity — education, research, and public service. One of the ways in which the University of Illinois College of Engineering attempts to meet this obligation is in holding the annual Engineering Open House. In this two-day program, engineering students, with help from the faculty, put the entire College of Engineering on display to visitors.

High school students from all over the state are invited to attend Open House each year. Besides the broader educational benefits of learning more about this important field, students interested in engineering as a career can talk with engineering students and professors about courses of study and opportunities in engineering.

This year Open House took place on March 11 and 12. Among the many items of interest that were shown or demonstrated were the three uranium-graphite and uranium-water subcritical assemblies, the betatron, the 3,000,000-pound tension and compression testing machine, the cyclotron particle accelerator, and the ILLIAC high speed digital computer. Information booths were established in all of the engineering departments, and every effort was made to answer visitors' questions about curricula, equipment, or policies.

Each "whisker" is a single crystal of pure iron capable of withstanding forces of more than 1,000,000 pounds per square inch and springing back to its original shape. These were on display at Open House.

SUMMER TRAINING INSTITUTE

Illinois high school students of high standing, ordinarily in the upper ten per cent of their classes, may soon have an opportunity to judge for themselves the engineering program offered at their state university. A six-weeks' program in science and engineering, supported by the National Science Foundation, will be held on the campus from June 13 through July 22. Students who will be high school seniors in the fall of 1960 are eligible for the program. The deadline for applications is April 15, 1960; award announcements will be made about May 1.

Applications and data sheets have been mailed to high schools throughout the state. This program is under the direction of Professor J. S. Dobrovolny, 117 Transportation Building, University of Illinois, Urbana, Illinois.

TOWARD A NEW SCIENCE

"Research is a cultural activity which embraces all problems related to the preservation and development of mankind." From this starting point, J. T. Tykociner, Research Professor Emeritus of Electrical Engineering, has presented a proposal for a new term, *zetetics,* the science of research, and has organized much of the present knowledge of research as a science, whatever its subject matter.

The detailed proposal and basic outline for zetetics are presented in a new paper-backed book, *Research as a Science — Zetetics,* published by Professor Tykociner through the University of Illinois Department of Electrical Engineering. The contents of this book are the result of years of study, investigation, and writing on this subject by the author.

In the Introduction, Professor Tykociner presents the importance of this science to mankind:

Research activity has now reached a stage of development unprecedented in its scope and its influence on human affairs. It involves more than a thousand branches of science and engineering; it gives occupation to about one per cent of the manpower of our country and consumes a considerable part of our national budget, amounting to more than the total budget twenty years ago (1939). The significance of research as a social phenomenon can hardly be realized fully without due consideration of the fact that it leads to new world situations, gives rise to new industries, creates new occupations, and serves as one of the main cornerstones in the structure of modern society. Research itself has become an industry, centered around hundreds of research laboratories and institutes. It now tends to become also a social institution on whose proper functioning depends our very existence and survival.*

* Reprinted by permission of the author.

Professor Tykociner emphasizes that the science of research is not concerned with the nature or administrative organization for conducting research. His aim is to establish a basis for the collection and systematization of all information about research itself, including the creative process. That is the knowledge, Professor Tykociner says, that leads to discoveries, inventions, and the solution of human problems.

Copies of Professor Tykociner's publication are available from the Office of Publications, 114 Civil Engineering Hall, University of Illinois, Urbana. The price is two dollars.

HALF A LOAF

Half a loaf is better than no bread, or so the idea has run in western civilization at least since the sixteenth century. The Physics Department of the College of Engineering is taking what comfort it can from this, as it occupies its new "half-building" on the east side of the Urbana campus. Physicists began moving into the completed half of their new building last September. Funds are not yet available for the second half.

Before the move into the new half-building, the Physics Department was housed in facilities constructed in 1909. With the exception of the betatron and cyclotron facilities, which are not used in undergraduate instruction, no new building was available to the Department between 1909 and 1959.

The history of the new Physics Building might be said to begin in 1937, when the Department requested an addition to the old Physics Laboratory Building, which had been their home since 1909. No funds were available, and World War II stopped new construction of this type.

In 1949 the Department expanded its work in solid state physics, and this work grew considerably in the following ten years. This expansion was squeezed into the attic and basement of the old building, in areas where researchers sometimes lacked headroom to stand upright at their work.

W. L. Everitt, Dean of the College of Engineering, appointed a College-wide Building Committee in 1954 (called the Space Committee, until Sputnik I opened the way to misunderstanding of this name). This committee made an objective approach to the needs of the whole College, and they put at the top of their list a new Physics Building, listing Electrical Engineering as next in priority and Civil Engineering third, as a part of a long-range program. From this recommendation came the present half-building and the projected plans for the other half.

A large part of the floorspace of the unbuilt half will be classrooms. Much of the remainder will be student

The new half-building stands ready for the addition of the other half when funds are available.

and research laboratories. When the second half is completed, space in the old building will be freed for other urgent needs of the College, particularly those of the Department of Mining and Metallurgical Engineering.

How long the Physics Department will have to get along with half a loaf depends heavily on the outcome of the Universities Bond Issue vote in the November elections. At that time the people of Illinois will be asked to decide whether the State is to be authorized to issue up to $195,000,000 in general obligation bonds, the money from which will be used for building facilities at the six State-supported institutions of higher education. A similar issue failed in 1958 — not because a majority was against it, but because public interest was so low that not enough people voted to provide the necessary minimum number of votes. Of those who voted, the majority were in favor of the issue.

If the Universities Bond Issue passes next November, prospects for funds for the second half of the Physics Building will brighten considerably. Physicists at the University of Illinois are anxiously waiting to see if they will have to continue to educate our future scientists and engineers on a "half a loaf" basis.

FULFILLING THE DEMANDS OF TOMORROW TODAY

The increasing complexities of the various fields of engineering require a stronger background in science than ever before. At the same time, the increasing responsibilities of the engineer in society require a broad understanding of the social sciences and the humanities. These developments mean that the high school should participate in preparing the student for a professional career in engineering even more than in the past.

For these reasons, the College of Engineering has found it possible and desirable to increase its entrance requirements. These new requirements will give the student the necessary background not only for engineering but also for almost all the fields of study in college, particularly in the sciences.

Freshmen entering the College of Engineering in the fall semester of 1963, or after, must meet the new requirements. In addition to the present requirements in English and mathematics, they will have to have at least two years of work each in science (physics, chemistry, or biology), social studies, and a foreign language. Such a background will make their college work more fruitful and, in the long run, will make them better prepared to take their places in industry as professional engineers.

Additional information regarding preparation for study in engineering is available from the Dean of the College of Engineering, University of Illinois, Urbana, Illinois.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 1, NO. 2, APRIL 1960

DIAMOND JUBILEE EXHIBITION

Fundamental research and education in engineering will be the backbone of tomorrow's technology. This theme will dominate the University of Illinois display in the 75th Anniversary Exhibit of the Illinois Society of Professional Engineers, May 4 through May 8, at the State Armory in Springfield.

The display, designed to keep the people of the State informed of the work in engineering being done at the University, will represent the three major areas of engineering endeavor: the processing of information, the processing of materials, and the processing of energy. For example, the Department of Electrical Engineering will exhibit a small device in the information processing area which will demonstrate principles of biological computers. These computers distinguish themselves from high-speed digital computers by their ability to interact with the operator as a living, intelligent organism would.

Among the materials processing exhibits will be one from the Mining and Metallurgical Engineering Department of gold-cadmium alloy, an unusual material that exhibits a rubber-like behavior. An identical display was previously shown by invitation at the World's Fair in Brussels. The Ceramic Engineering Department will display high temperature materials and dielectric components of miniaturization systems such as those used in rocketry. Mechanical Engineering will enter a display which will indicate how experimental work is being conducted to measure the temperature distribution involved in the machining of metals.

The energy processing displays will include an exhibit which will show the appearance and functions of the University's new 100-kilowatt training and research reactor. Some of the other exhibits in this area will be a 140-220 kmc/s microwave system from the Electrical Engineering Department and an explanation of the Aeronautical Engineering Department's work on the plasma jet, a thermal device used to study certain space propulsion problems.

The University display will be manned at all times by personnel who will be able to answer visitors' questions about the displays, the Engineering College, and the study of engineering at the University.

USES FOR THE "USELESS"

Better roads at less cost would please highway officials and taxpayers alike, and toward this end the U. of I. Civil Engineering Department is hard at work. Research now in progress under the direction of Professor George W. Hollon is studying the performance of various road building materials, with present concentration on low quality and waste materials that are now considered useless.

For the past four years, Professor Hollon has been experimenting with slag and fly-ash material that is produced as a by-product by power plants. Illinois power plants alone annually produce 1,500,000 tons of this material, which is now not only useless but an expense to the company because it has to be hauled away and dumped. Low quality pit-run gravel, which is now considered waste material, is also being studied as an aggregate.

This research is now being given an important boost by the acquisition of a test facility for evaluating the performance of these materials in actual service. The machine, designed to "travel" thousands of miles and yet go nowhere, is soon to be erected by the Civil Engineering Department.

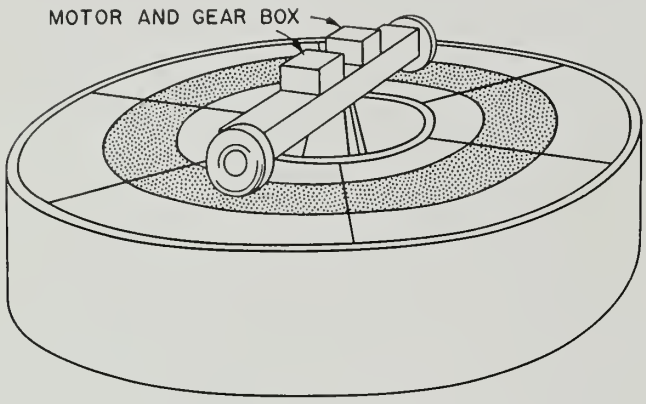
This piece of equipment will be a round test track 26 feet in diameter and divided into six segments, one consisting of the Illinois State Highway Department's standard crushed stone base construction, and the others of experimental construction. It will give each test section the equivalent of a year's wear each week.

Two truck wheels at ends of a beam pivoted in the middle of the track will spin along, moving in and out over a 2½ foot path, carrying loads varying from 1,700 to 3,000 pounds per wheel.

Four industrial sources have pledged funds to support the work. They are National Lime Association, Wash-

ington, D.C.; Pozzolan Products Co. and Marblehead Lime Co., both of Chicago; and Poz-O-Pac Company of America, Philadelphia.

The first three years of work with the new test track will be devoted to these "useless" aggregate fly-ash materials in combination with lime. These final experiments will test Professor Hollon's belief that such materials will make excellent, durable, and low-cost roadways. The final two years of research are scheduled for tests on the stabilization of natural soils by the use of lime.



CIRCULAR TEST TRACK

It is interesting to note that such materials are almost identical to those used by the ancient Romans in their roads, many of which are still in use after all these centuries.

MORE MILEAGE FROM ENGINEERING MANPOWER

A partial solution to the shortage of engineers lies in the training of more engineering technicians. The technician serves as an excellent assistant to the engineer in such activities as preparing drawings, conducting tests, gathering and summarizing information, and making cost estimates and time studies. By doing these things, the technician relieves the engineer of routine duties and leaves him more time to make use of his training and experience at the highest professional level. The number of technicians now in this country totals approximately one for every engineer. Informed estimates are that a ratio of three technicians to every engineer would be optimum for the most efficient use of engineering manpower.

Training for the engineering technician usually consists of from one to three years of study after high school, with two years being most common. This "technical institute" training is a practical education in the methods and techniques of engineering without as much emphasis on the theoretical background, the "why" that is so important to the engineer. Technical institute training is usually specialized in such fields as electronics, drafting, machine design, and so on.

In response to the growing interest in technical institute education, a committee was recently appointed by the College of Engineering at the request of the Office of the Superintendent of Public Instruction of the State of Illinois, to advise that office about the establishment of curricula for proposed technical institutes in Illinois. This committee will provide counsel to the State concerning the alignment of curricula and course content with the accreditation standards of the Engineers' Council for Professional Development, the national accreditation organization for engineering at both the collegiate and technical institute levels.

The University of Illinois committee is made up of representatives from various engineering departments. Its chairman is Professor J. S. Dobrovolny, Head of the Department of General Engineering.

TITANIA RECRYSTALLIZING PORCELAIN ENAMELS BULLETIN

If the finish on your new stove lasts longer and looks better, the reason may well be the use of titania enamels. These highly durable and acid resistant coatings have been developed for commercial use in recent years and are coming into wide use on appliances and other products in the home and in industry.

Many years of research, study, and data accumulation on these porcelain enamels have been put into Experiment Station Bulletin 456, "Titania Opacified Porcelain Enamels." This is the first time that such a large mass of data on this subject has been put into such a convenient form. The bulletin deals with crystallization, composition of enamel glass, properties of titania enamels, processing, and special applications of titania enamels. There is also a bibliography of 148 titles which should interest the ceramic engineer working in this area of research.

This Bulletin contains 49 pages, 32 figures, and 11 tables. It is available from the Engineering Publications Office at the price of one dollar.

HUNTING FOR OIL WITH ILLIAC

When a cook wants to make rabbit stew, he first has to catch a rabbit; when a petroleum engineer wants to develop an oil well, he must first find the oil. Just as rabbit hunting is both an art and a science, so is hunting for petroleum. Professor V. S. Tuman, U. of I. petroleum engineer, is doing fundamental research which promises to make petroleum prospecting more of a science, establishing a background of usable knowledge in the field and making a valuable tool for the use of oil companies.

Professor Tuman points out that whenever an oil well is drilled it is a common practice to prepare a set of well logs which indicate some of the physical properties

of the sands encountered. These logs, intricate wiggly lines on long strips of paper, make possible the computation of the porosity and saturation of fluids in the various strata. From the calculations of these logs, as well as from other available information, the petroleum engineer can decide whether any of the strata deserve further consideration. If the evaluation of a particular stratum in a developed area is favorable, then the well log data on the same stratum from surrounding wells, sometimes twenty to thirty of them, are also analyzed. Of course such a cross-analysis is impossible in the case of a wildcat well, where the prediction has to be based just on the data from the single well.

Normally, only a few strata in any given well are evaluated. The amount of time and effort involved in such an analysis usually prohibits the evaluation of all the sands encountered. Ideally, however, petroleum engineers would have evaluations of all strata of all previously drilled wells from which to make their predictions. Professor Tuman has devised a system to use ILLIAC, the University's high speed digital computer, to make this possible.

Professor Tuman is now working on an electronic device that will translate data automatically from oil well logs to tapes which can be used in the ILLIAC. ILLIAC will be able to complete computations on all the sands found in a well, a job which ordinarily cannot be done at all, in a matter of minutes. This will allow the petroleum engineer, who still must make the final decision, to make far quicker and more accurate predictions than ever before. These computations will be usable for any well in any area, once the technique is perfected.

Eventually a large number of water or oil-bearing strata will be evaluated and catalogued, making a tremendous mass of background knowledge available to the petroleum engineer. Obviously the number of water-bearing strata in this study will outnumber the oil-bearing strata by a large factor, but this will also be extremely useful knowledge. As the system develops, each new well will mean, rather than just a new problem to be solved, a new addition to the background of information being accumulated.

Professor Tuman estimates that he will be making calculations for wells of the Illinois oil basin within two years. He hopes not only to be able to indicate immediate possibilities for new production, but also to discover fundamental information about underground oil strata and underground movements of water.

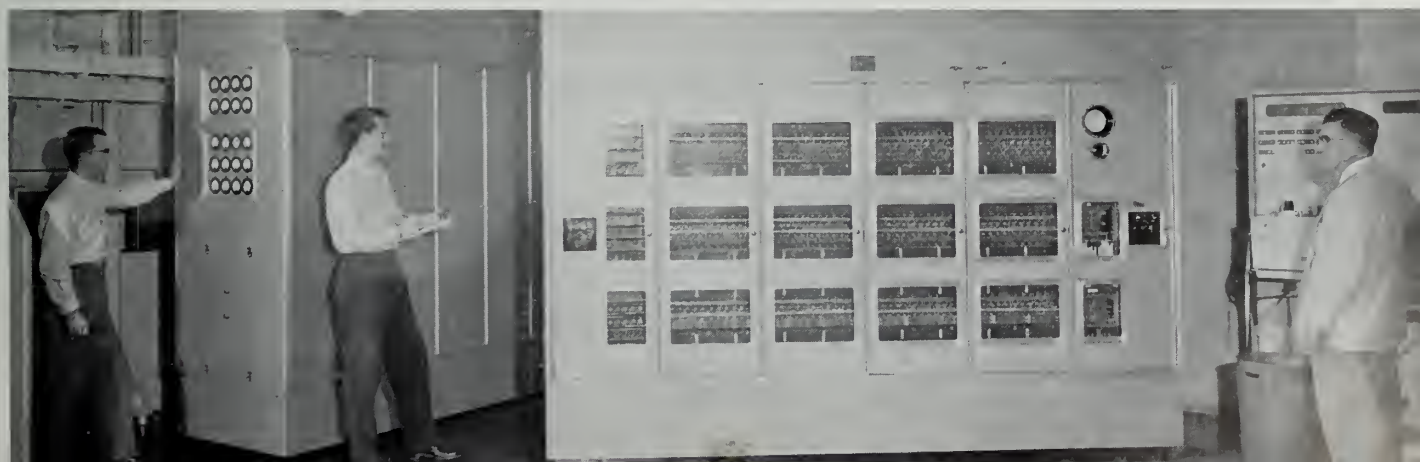
FOR CLOSER TIES WITH INDUSTRY

Mechanical engineering students and faculty will have the latch string out for people in industry at the annual Industrial Night, April 27, on the Urbana campus. Sponsored by the student chapter of the American Foundrymen's Society, Industrial Night is part of a yearly program designed to promote closer ties between industry and mechanical engineering on the University campus.

Each year the Central Illinois Chapter of AFS, with the support of industry, invites mechanical engineering students at the University to a meeting in Peoria. This meeting includes talks by engineers and engineering educators and a visit to industries in the Peoria area. Each spring, the University's mechanical engineering students and staff return the compliment by inviting people from industry to the Industrial Night, which includes a dinner at the Illini Union, the awarding of industrial scholarships and fellowships in mechanical engineering, and a talk by a prominent engineer from industry. Informal tours of the campus are also a part of the program for those who are interested. This year four Foundry Educational Foundation Scholarships for undergraduates and the Wheelebrator Graduate Fellowship will be awarded.

The speaker for the 1960 Industrial Night will be Kenneth A. Stonex, Assistant Director of the General Motors Proving Grounds at Milford, Michigan. Mr. Stonex will speak at 7:30 p.m. in Room 100 Physics Building about the work at the Proving Grounds on automobile safety.

ILLIAC, the high speed digitol computer designed ond built ot the University, hos odded petroleum prospecting to the many engineering research areas in which it is o valuable tool.



The talk and all other activities of the Industrial Night are open to the public and everyone in industry is welcome and is being encouraged to attend. Further information concerning Industrial Night can be obtained from Professor James L. Leach of the Department of Mechanical Engineering.

INFORMATION ABOUT THE DEPARTMENTS

People who are coming to the University to work or study have many questions about curricula, prerequisites, scholarships, and other aspects of campus life. Every department in the College of Engineering has brochures which attempt to answer these questions and to tell where further information can be obtained. Two new brochures, one listing the curriculum in Ceramic Engineering and the other describing the new graduate program in Nuclear Engineering, have recently been issued.

The Ceramic Engineering folder tells about the four-year undergraduate program leading to a B.S. degree, and the graduate program leading to M.S. and Ph.D. degrees. It gives a full schedule of the courses required in the undergraduate program.

The Nuclear Engineering brochure describes the new program leading to an M.S. degree in Nuclear Engineering. It also tells how a Ph.D. candidate in one of the other departments of engineering can elect nuclear engineering as a minor in his program. It discusses admissions, facilities (including the new 100-kilowatt training and research reactor), University fellowships, and other items of interest.

These and other brochures about the engineering departments at the University of Illinois are distributed by the Engineering Publications Office.

A SEMINAR FOR INDUSTRY

A two-day seminar on aids in design room management will be held for people in industry by the General Engineering Department on April 28-29. Topics will be discussed not only by University people, but by men from such companies as Magnavox, Procter and Gamble, General Electric, Convair, Kearney and Trecker, Delco-Remey, and Bell Telephone.

Some of the topics relating to design room techniques and management will be the improvement of managerial effectiveness, the use of models as an aid to design, microfilming, the use of machines in engineering drawing, the automation approach, and several other topics on drafting practices.

Although this annual General Engineering Seminar will be attended by industry personnel from all over the country, no shortage of room is anticipated and no final application date has been set. Expenses will consist of the regular $20.00 tuition fee and room and board. Anyone who would like more information on the program may write to Professor J. S. Dobrovolny, 117 Transportation Building, University of Illinois, Urbana, Illinois.

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ENGINEERING OUTLOOK
114 CIVIL ENGINEERING HALL
UNIVERSITY OF ILLINOIS · URBANA

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 1, NO. 3, JUNE 1960

ENGINEERING RESEARCH SUMMARIZED

The Engineering Experiment Station at the University of Illinois had a research income of more than $6,496,000 in the fiscal year ending in 1959. The staff of the College of Engineering consisted during that year of 526 faculty members with the support of 377 nonacademic staff members, such as laboratory mechanics, technicians, and office personnel, and 423 graduate assistants. They were engaged in 324 research projects. Of these, 211 were sponsored by outside sources, including 31 private companies, 16 industrial associations, 2 private foundations, and 51 federal and state agencies.

Of the nearly six and a half million dollars in research income, approximately $5,094,700 came from various federal government sources, $380,300 from industry, private foundations, associations, and operating agencies of the State of Illinois, and $1,021,000 from the general funds of the University.

These figures are a part of the information about engineering research at the University of Illinois, as contained in the *Summary of Engineering Research: 1959,* now available on request from the Engineering Publications Office. This *Summary* outlines the policies and operation of the Engineering Experiment Station and summarizes the research of each engineering department, project by project. The advantages of engineering research at a large university are illustrated by brief descriptions of groups and facilities outside the College of Engineering which cooperate with the engineering research program.

This is the second of an annual series. It is intended as a general guide to research in engineering at the University, and is not a detailed technical presentation of any specific area of work. For the convenience of those interested in more detailed information, publications are listed after each project and the names of the investigators in charge are given.

NOT EVEN HOUDINI . . .

Magic is not generally considered the province of the engineer. He deals with physical phenomena and reasonable explanations. Yet by some magic or other, electrical engineers at the University of Illinois are carrying on their educational and research functions in facilities designed by a department less than one-quarter their present size.

Fifteen years ago, in 1945, the Electrical Engineering Department had a staff of twenty, 196 undergraduate students, and 2 graduate students. Expecting an undergraduate enrollment of 400 in a more normal year, the Department requested a new building. Funds were made available, but post-war prices rose sharply. There was only money enough to build one-third of the building originally requested and approved. In 1949, the one-third building was completed. The Department had grown some in the four years since the request, but growth had been anticipated. Engineering could meet the Department's space requirements without reference to the occult.

Eleven more years have passed. The explosive expansion of electrical engineering in an age of missiles, computers, and super-accurate guidance systems has been followed by explosive expansion of electrical engineering education and research. The department that in 1945 had 20 staff members and 196 undergraduate students now has 91 faculty members, 79 nonacademic staff members, 1146 undergraduate students, and 222 graduate students. Growth of the research program has more than kept pace.

The job they are doing is a good one, but there are limits even to an engineer's magic. A planned addition to the Electrical Engineering Building would greatly relieve the crowding, but funds are not yet available.

The Universities Bond Issue, to be voted on by the people of Illinois next November, does not specify what funds shall be made available for what buildings — or even for which institution. But if the Universities Bond Issue passes, electrical engineers at the University will have brighter hopes for the addition to their building.

Their magic charms are wearing thin. They fear that soon engineering reality will force restriction of the num-

ber of electrical engineers that can be adequately trained, despite growing needs in industry and defense. The voters of the state need to be informed of the needs and importance of higher education so that they may decide the fate of the Universities Bond Issue wisely next November.

The final decision belongs to the people of Illinois.

THE BEST FROM THE BEST

The future of our civilization may depend on how well we develop and utilize our nation's "brainpower." In this regard, helping the superior student make the most of his ability is a challenge to all educators. The College of Engineering will begin a new program next fall to meet that challenge.

The Edmund J. James Scholar Program was initiated by the University for freshman students entering in September, 1959, to recognize and encourage outstanding scholarship. The program is expected to help attract outstanding high school graduates and develop their talents to the fullest.

The James Scholar Program operates in conjunction with undergraduate honors programs in the various colleges and schools of the University. Beginning in September of this year, the College of Engineering will have an Honors Program in Engineering. This program will provide the superior student with greater opportunities and greater flexibility than in the normal curriculum and a climate for deepened development.

Minimum requirements for the Honors Program for entering freshmen include admission to the University as a James Scholar. Honors students will be expected to maintain a grade point average of 4.5.

These students will be assigned to special advisors and be encouraged to satisfy course requirements by proficiency examinations or to move directly into advanced level courses when advisable. Special sections will be established for them in some courses. In these sections, the high level of student ability will make it possible to cover more material in greater depth than is normally possible.

Upperclassmen may have a portion of their normal curriculum requirements waived and other courses substituted. Special activities will also be available, including seminars and projects.

Honors students successfully completing their programs will have Honors status indicated on their diploma in acknowledgment of the special work they have done at the University.

EDUCATION THROUGH RESEARCH

Laboratory exercises in which the professor doesn't know the answer ahead of time will occupy some outstanding University undergraduate students in the coming months. Under grants from the National Science Foundation, approximately twenty undergraduates in Electrical Engineering, Theoretical and Applied Mechanics, and Chemistry and Chemical Engineering will work under the direction of faculty members in actual research projects. The work begins this summer and in some cases will extend through the coming academic year.

An event at Mechanical Engineering's Annual Industrial Night April 27 was presentatian af Faundry Educatianal Faundatian schalarships ta faur autstanding saphamares. Presenting the schalarships was C. F. Stram, vice president af Griffin Wheel Ca. (left). Students wha received schalarships were R. W. Katrba (Chicaga), C. H. Janes (Flassmaar), and C. H. Ernst (Gibsan City). Praf. J. L. Leach (right) is faculty advisar af the student chapter af the American Faundryman's Saciety. G. R. Bayd (Urbana) was awarded a schalarship but was nat present.

The purpose of this program is to interest superior students in research and to give them experience in using the scientific method and actual research procedures. The program is an additional way in which the College of Engineering is able to use its extensive research program to strengthen its educational function. The students' interest in their work should be heightened considerably with the realization that they are "playing for keeps" in their work, searching for new information, and not just going through the routine laboratory exercises.

The National Science Foundation grants will be administered by Professor W. E. Miller in Electrical Engineering, Instructor S. Russel Keim in Theoretical and Applied Mechanics, and Professor J. C. Martin in Chemistry and Chemical Engineering. The students will work on various projects under faculty members of those three departments.

In Electrical Engineering, a senior in engineering physics will work under Professor A. A. Dougal in the area of plasma physics and the problem of controlled thermonuclear reactions. In his work he will be dealing with gasses at temperatures comparable to those on the surface of the sun. A senior in Electrical Engineering will study the nonlinear microwave properties of plasmas, an area in which little work has been done to date. This will be a part of the microwave research program under the direction of Professor Paul Coleman.

In Theoretical and Applied Mechanics, eight students this summer will participate in the program, under the direction of Professors A. C. Bianchini, C. E. Taylor, H. T. Corten, and W. J. Worley. Their work will be in the areas of dynamics and vibrations and mechanics of solids. In each case, the work of the student will be associated with existing research programs but will be carried on as a problem in itself, exploring aspects of the general research program that might otherwise have to be neglected for want of staff.

The ten students in Chemistry and Chemical Engineering will be working in the fields of biochemistry, organic chemistry, and chemical engineering. The chemical engineers will work under Professor J. A. Quinn, who is directing the department's research program on fluidization, an important phenomenon in many chemical engineering operations.

NEW ENTRANCE REQUIREMENTS

Students wishing to enter the College of Engineering in September of 1963 will have to meet a new set of requirements, including more high school work than is now required in science, social studies, and languages.

Engineering requires a stronger background in mathematics and science now than ever before. At the same time, the increasing social responsibilities of the engineer require an understanding of men and society. This understanding can be aided by a study of the social sciences and humanities. These developments mean that the high school should participate in preparing the student for a professional career in engineering even more than in the past. High schools offer a wide choice of courses in languages, the social sciences, mathematics, the sciences, and English, and are capable of such participation.

The new requirements emphasize the importance of good preparation in high school in all these basic areas of study. Meeting them will give the student the necessary background for almost all fields of study in any university.

Details of the requirements are in a pamphlet, "New Entrance Requirements," recently published by the College of Engineering. Copies of this pamphlet are avail-

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ORDER FORM — send with remittance to Engineering Publications, 114 Civil Engineering Hall, University of Illinois, Urbana, Illinois

☐ Bull. 456, *Titania Opacified Porcelain Enamels,* R. D. Shannon and A. L. Freidberg. *One dollar.*

☐ Circular 68, *A Comparison of the Performance of Various Room Heating Units Used in the I=B=R Research Home,* Warren S. Harris and L. N. Montgomery. *Fifty cents.*

☐ Reprint 61, *Progress Reports of Investigation of Railroad Rails,* Ralph E. Cramer. *Fifty cents.*

☐ *A Summary of Engineering Research: 1959.* No charge.

☐ *Engineering Departmental Reports and Theses: 1958-1959.* No charge.

☐ *New Entrance Requirements.* No charge.

able to interested parents, students, and educators, on request from the Engineering Publications Office.

The requirements are:

Subject	*Required Units*	*Recommended Additional Units*
English	3	1
Algebra[1]	2	
Plane Geometry	1	
Trigonometry[1]	½	
College Preparatory Mathematics		as available
Science[2]	2	1
Social Studies	2	1
Language[3]	2	as available[4]

[1] Students who have only one unit in algebra and one unit in plane geometry may be admitted on condition that the deficiency is removed in the first year.

[2] Required science must include at least one unit each from two of the following subjects: physics, chemistry, and biology. Botany and zoology may be substituted for biology. General science may not be used as a required science subject, but may be used as an elective subject.

[3] Required language must be two units in one language. Students deficient in language may be admitted on condition that the deficiency be removed during the first two years.

[4] It is recommended that additional credit be earned in the same language that was presented for entrance credit. However, if the two required units of language are Latin, the additional credit should be in a modern language.

MESSAGES FROM THE SKY

University of Illinois antenna research went to new heights recently when satellite Transit I-B flashed across the skies bearing a spiral antenna developed by the Electrical Engineering Department's Antenna Lab. Making a protruding antenna unnecessary, this spiral can receive radio messages over an extremely wide band of frequencies, from 54 to 216 megacycles. Spirals and other unique antenna designs developed at the University are being used by several research groups for radio direction finding, radio astronomy, and moon-echo study.

The Antenna Laboratory has conducted work on basic electromagnetic theory and applications to antennas for high speed aircraft for the past ten years. This work has involved both the transmission and reception of electromagnetic waves of various types. The University of Illinois Foundation holds a number of patents in the antenna area, as a result of work conducted in the University's Antenna Laboratories.

Other research programs on radio wave propagation and reception include facilities at the University for radio direction finding which are among the most extensive and complete in the country. Two antenna sites are in operation, with three antenna arrays. The largest is a wide-aperture Wullenweber-type array 990 feet in diameter on a 40-acre site with a laboratory building at the center of the antenna array. The other antennas include two small-aperture Adcock and satellite tracking installations located on a separate 80-acre site. The aim of the research is to advance the art of direction finding by comparing the various systems and to obtain basic information about the propagation of ionospherically-reflected radio waves.

Two other antennas deserve mentioning. The 28-foot parabolic Moon Beam Antenna, mounted on the Electrical Engineering Building, is used to receive signals reflected off the surface of the moon from transmitters in New Jersey and Canada. These radio signals, taking only 2½ seconds to make the half-million mile journey, furnish valuable information about the ionosphere.

The other antenna is the great radio telescope being constructed near Danville, Illinois. Receiving elements, mounted on towers 155 feet above the 400- by 600-foot ravine which serves as a huge reflector, will consist of cone-shaped logarithmic spiral antennas which are near relatives of the one now on Transit I-B. Construction of the radio telescope will be completed by fall. Addition of this installation will give the Electrical Engineering Department one of the most complete antenna facilities in this country.

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ENGINEERING OUTLOOK
114 CIVIL ENGINEERING HALL
UNIVERSITY OF ILLINOIS · URBANA

ENTERED AS SECOND-CLASS MATTER, URBANA, ILLINOIS

ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 1, NO. 4, JULY 1960

A DRIVE FOR SPACE

A new type of electrical engine for space flight is being studied at the University of Illinois by Professor Charles D. Hendricks, Jr. The investigation, being conducted in cooperation with the Thompson Ramo Wooldridge Corporation, is primarily concerned with the basic physics of liquid metals for use as working fluids in thrust-producing engines. Experiments involve placing an electrical charge on tiny droplets of liquid metals, enabling the droplets to be accelerated by electrical fields to propel a vehicle in space as do exhaust gases from an ordinary rocket.

Professor Hendricks has just returned to the project from visiting research laboratories in Tokyo, Calcutta, Rome, and Paris. During this trip he addressed the Japanese Rocket Society in Tokyo and gave seminars at two science institutes in Calcutta. The seminars were devoted to discussions of experimental work in gaseous electronics and plasma physics in the University of Illinois Electrical Engineering Department.

FIGHTING HEAT WITH ADHESIVES

One of the greatest problems faced today by designers of high speed aircraft and rockets is finding materials which are strong, light, and heat resistant. One group of researchers in the U. of I. Department of Ceramic Engineering, directed by Professor D. G. Bennett, has found a promising solution in metal panels laminated to honeycomb layers by glassy bond and air setting adhesives.

Such panels honeycombed with organic adhesives will not resist temperatures much above 500° F., but this study is primarily concerned with inorganic adhesives which, while very strong, will permit the panels to withstand over 1000° F. at several thousand psi in tensile shear for extended periods of time. Professor Bennett points out that the program is now based on a target temperature of 2000°, and that progress is being made toward solving this problem which now stands in the path of astronautics and rocketry.

TWO KINDS OF SPACE FOR AERONAUTICAL ENGINEERING

Space travel has put the aeronautical engineer into the international limelight. Missiles and space ships have become a matter of national policy and prestige, and perhaps of national survival.

With the largest undergraduate enrollment in aeronautical engineering in the United States, the Aeronautical Engineering Department at the University of Illinois is vitally concerned with keeping its teaching and research programs up to date with the latest developments in the field. This country's continued progress in aircraft, missiles, and spacecraft is dependent on a supply of young engineers trained to handle tomorrow's problems as they arise.

Another kind of space problem stands in the way, however, and this one can't be solved by aeronautical research. In its sixteen years of operation, the Aeronautical Engineering Department has had only "second-hand" laboratory and office space given to it from the overcrowded facilities of the other engineering departments. Their offices are in the Transportation Building and their laboratories and shop space are in the old Locomotive Laboratory and the old Machine Tool Laboratory. Six miles away, at the University airport, the Department has two Quonset huts.

A recent departmental report comments that the two laboratory buildings on the campus were no longer adequate for the purposes for which they *were* designed, so the Aero Department is now trying to use them for purposes for which they *were not* designed. Low pressure air sources are at the airport and high pressure air sources are six miles away on the main campus, so both cannot be readily used for the same set of tests. Laboratory work is frequently severely limited in power and capacity.

The Department's research program is closely coordinated with teaching. Members of the faculty have been associated with missile development for several years. Research under way at present includes hypersonic

aerodynamics, plasma physics, magnetogasdynamics, high-temperature structures, aircraft performance and stability, and propulsion systems. This includes highly theoretical studies of interplanetary flight.

To maintain its teaching and research program at the forefront of knowledge in the field, the Department has requested its own building for laboratories, offices, and classrooms. This is to include such essential laboratory facilities as low, medium, and high pressure air supplies, vacuum systems, high temperature sources, and adequate energy supplies. Funds are not now available, but they may become available early enough to prevent further delay in the development of aeronautical engineering at the University of Illinois if the Universities Bond Issue is approved by the voters next November.

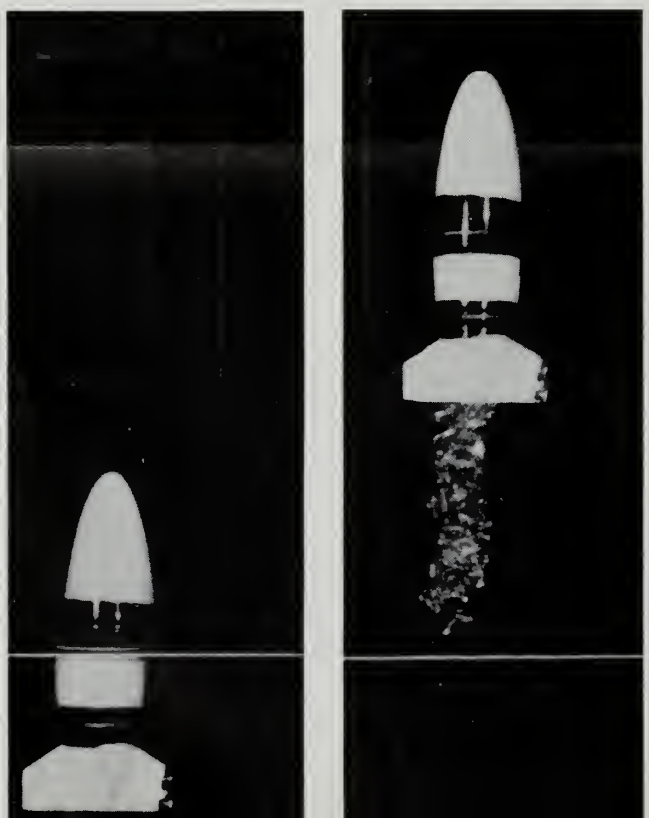
The Universities Bond Issue will not specify the buildings to be built, or even how much money goes to each university. But it will make funds available for allocation by the State Assembly for needed buildings on the campuses of Illinois' universities. With such funds available, the acute needs of the Aeronautical Engineering Department will be a step nearer to being met. The passage of the Universities Bond Issue will be a step toward assuring that our progress into outer space will not be delayed by lack of teaching space right here on earth.

A SILENT SOUND FOR SURGERY

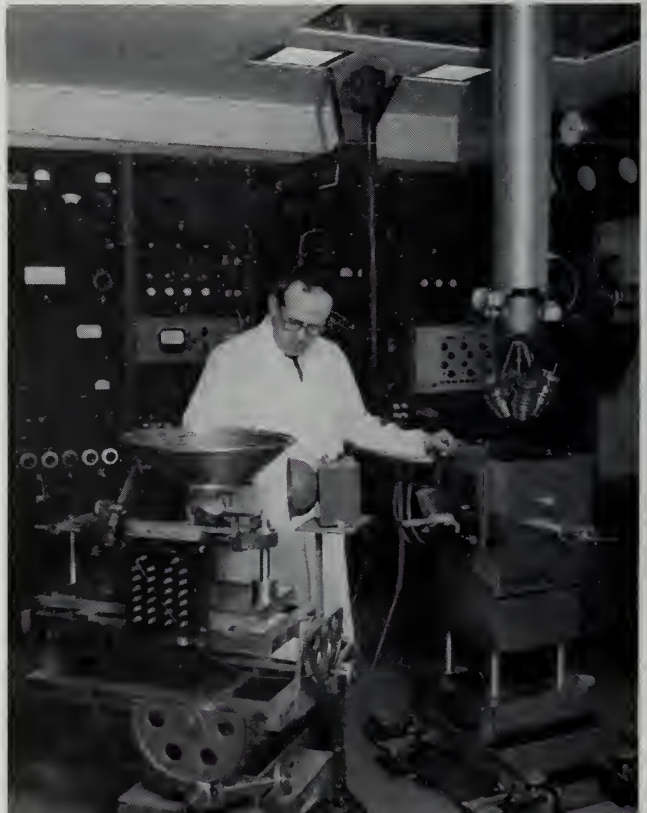
The Biophysical Research Laboratory of the Electrical Engineering Department has discovered that high intensity focused ultrasound can be used, under precisely controlled dosage conditions, to produce selective changes in the central nervous system. This discovery provides a new method of performing brain operations. Both research on experimental animals and ultrasonic human neurosurgery are in progress at the present time, the latter work being carried out in collaboration with the Division of Neurosurgery of the State University of Iowa. Work being done at the University of Illinois, directed by Dr. William J. Fry, consists of dosage, anatomic, and behavioral studies on large animals.

The instrumentation for this work, as well as the basic discoveries on experimental animals, was developed at the University of Illinois. It is the first system that permits precision ultrasonic irradiation of biological systems in the megacycle per second frequency range at high intensity levels. Ultrasonic techniques show great promise in brain surgery techniques, three dimensional

High-speed motion pictures, taken at 1,000 frames per second, reveal that as a missile-shaped body passes from water to air there is little surface disturbance, slight effect on speed or direction, but considerable water exiting with the missile. Photos show (left) a model 4 inches long passing from water to air, (right) the model after exit from the water. This study of water exit hydraballistics is being done by Professors James M. Robertson and Marlyn E. Clark of the Department of Theoretical and Applied Mechanics. The research is sponsored by the Navy's Office of Naval Research.



Professor William J. Fry is shown with a portion of the instrumentation for focused ultrasonic beam irradiation of selected regions of the brain. The four-beam focusing irradiator is shown mounted on a tube projecting through the ceiling of the room. This tube supports and moves the irradiator. Electronic control instrumentation is shown mounted in the wall in the background. The calibration tank is in position immediately below the irradiator. The pan which supports the degassed sterile solution which acts as a transmitting medium for the sound is shown in position over the skull.



mapping of brain mechanisms, resolving micro-structures by means of ultrasound microscopes, and treatment of such disorders as Parkinson's disease, cerebral palsy, and intractable pain of patients with phantom limb and amputation stump pains. One of the current projects involves the study of tumor control through ultrasound irradiation.

NUCLEAR ENGINEERING STUDENTS SPONSORED

Eight graduate students in nuclear engineering at the University of Illinois attended the sixth annual meeting of the American Nuclear Society in June with the sponsorship of ANS and interested private companies. The sponsoring companies were the Commonwealth Edison Company of Chicago, General Atomic Division of General Dynamics of San Diego, *Nucleonics* magazine of New York, and the Nuclear Development Corporation of America, White Plains, New York. The financial aid allowed the students to attend two days of the meeting.

BRITTLE FRACTURE MECHANICS

Under certain conditions some structural steels fracture with a very small amount of deformation and a correspondingly small amount of energy absorption. During the past fifty years many structures, including ships, oil storage tanks, pressure vessels, and bridges, have failed suddenly and catastrophically in this manner. Such brittle fractures have been studied for a long time in the University of Illinois Civil Engineering Department. A research group directed by Professor W. J. Hall is presently conducting a fundamental investigation to identify the significant parameters associated with the propagation of brittle fractures. The most recent studies have involved measuring the strain field surrounding the tip of a propagating fracture and the fracture speed in wide steel plates. Reports describing this work are available from the Ship Structure Committee, National Academy of Sciences — National Research Council, Washington 25, D.C.

WORKING ON THE RAILROADS

All railroads in the United States and Canada send rails which have failed to the University of Illinois Theoretical and Applied Mechanics Department for examination. The University has a great deal of experience in this field, having instituted a program of railroad engineering back in 1898.

The method of investigating rail failure specimens is both mechanical and metallurgical. In the past year alone twenty-five reports were prepared for different railways, showing seventeen different causes for the failures. The ultimate goal of such investigations is the prevention of such failures through the use of better materials and design features.

Reprint No. 61, "Progress Reports of Investigation of Railroad Rails," by Professor R. E. Cramer has just been published, summarizing the investigations and findings of 1959 and describing testing apparatus and methods at the University of Illinois. It is available for fifty cents from the Engineering Publications Office, 114 Civil Engineering Hall, University of Illinois, Urbana.

ENGINEERING MECHANICS SYMPOSIUM

The first class in the new engineering mechanics curriculum at the University of Illinois was graduated in June. The fifteen men in the class culminated their studies on June 4 with the First Senior Symposium on Engineering Mechanics. At the Symposium, seven papers were presented by graduating seniors. These papers were on free torsional vibration of an elastic cylindrical bar mounted in a continuous elastic support, a discussion of the triaxial state of stress in an extremely thin brazed joint, the effect of biaxial stresses on rapid crack propagation, the soap film and its application, analysis of the influence of initial crookedness on column strength, specific work as a criterion for simple shear strain definition, and free vibration of a continuum with damping characteristics.

A limited number of copies of the papers in this program are available as Theoretical and Applied Mechanics Report 165.

DRAFTING TIME IS MONEY TOO

Engineering drawing has a number of fundamental traditions, among which are the methods of transferring measurements between orthographic views, the arrangement of these views, and the manner of drawing isometrics. Professor Wayne L. Shick of the University of Illinois Department of General Engineering has devised a new drafting system which allows *direct* projection between front, top, side, and isometric views.

An improvement on traditional methods, the United Drawing System permits more accurate drawings to be made with less time and effort. Isometric and orthographic views are integrated, making the isometric projection a direct check on the orthographic views. The movable part of the system is simply a plastic quadrangle which operates against three fixed guide strips. The University of Illinois Foundation has applied for a patent on the device.

The United Drawing System was presented at the an-

nual meeting of the American Society for Engineering Education in June 1960. The system will be published in the leading drawing texts in 1961. Requests for further information may be directed to Professor W. L. Shick, 210 Transportation Building, University of Illinois, Urbana.

WOMEN ENGINEERS

Miss Leone Murphy of Bellwood, Illinois, proved this June that the College of Engineering at the University of Illinois is not strictly the domain of the male student. She did this by graduating with a bachelor's degree in ceramic engineering. In five years at the University, she managed to also include some of the courses more conventionally taken by women in college. These included classics, mythology, ancient history, Greek tragedy, economics, accounting, and home economics.

Although she was the only woman graduating in engineering this June, Miss Murphy was not the only woman in the College of Engineering. During the 1959-60 academic year there were 12 women enrolled in the College.

GRANT AIDS HIGH PRESSURE STUDIES

A $50,000 unsolicited and unrestricted research grant has been awarded to Professor Harry G. Drickamer of the Chemical Engineering Department by the American Chemical Society. This grant-in-aid is given to support the work of an outstanding scientist selected for accomplishments in basic research. Professor Drickamer is internationally known for his work on properties of matter at high pressure. His group has developed apparatus to study materials optically at over 200,000 atmospheres.

The $50,000 grant will be used to support an extension of this work in the future.

AN ENCYCLOPEDIA OF WELDED STRUCTURE FATIGUE

A book discussing the available information and conclusions on the fatigue strength of welded structural connections is being written by Professor W. H. Munse. The result of a study for the Welding Research Council, the book should serve as a comprehensive guide for engineers who are concerned with the fatigue of welded structures. Publication plans are still indefinite.

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ENGINEERING OUTLOOK
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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 1, NO. 5, SEPTEMBER 1960

A REPORT TO INDUSTRY

OUR PRODUCT: TRAINED MANPOWER

A total of 767 undergraduate engineering students received their degrees during the year 1959-60. This period included the summer of 1959 (125), the semester ending in February 1960 (265), and the semester ending in June 1960 (377). Of this total, 437 were employed by industry at an average starting salary of slightly over $525 per month.

Of the 330 remaining students, 64 entered the armed services and 142 went into graduate schooling. The other 124 were foreign students who were returning to their countries, men who were on leave of absence from industry to further their educations, people who were graduating in absentia, and a handful of graduates who still hadn't accepted jobs.

During the 1959-60 year, 651 companies conducted 11,182 interviews on the campus. Starting salary offers showed a continued upward trend during the period, averaging $514.89 in August 1959, $529.75 in February 1960, and $531.82 in June 1960. These salaries were based on a 40-hour work week. The industries which took most of the graduates were electronic, radio, and television; aircraft and missile; light manufacturing; heavy manufacturing; county, state, and federal governments; and basic metal industries. These industries hired over 75% of the graduates who were employed during the year.

Trends seem to be toward more company visits to the campus, more interviews of prospective graduates, higher starting salaries, extremely heavy demands for electrical engineers, mechanical engineers, physicists, and mathematicians, and more demands for advanced degree holders. The growing demand for engineers with graduate degrees is accompanied by the increasing number of students who are entering graduate school.

MACHINES CAN'T SAY "MAYBE"

How well can a man and a computer work together? The University's Coordinated Science Laboratory recently completed a series of experiments involving such a partnership — and found some interesting answers.

The research, sponsored by the Army, the Navy, and the Air Force, was designed to test the capabilities of automatic and partially-automatic air defense systems during a series of simulated high-speed bombing raids. In the dispatching of interceptors, "human" decisions were made by an experienced naval officer and automatic decisions were made by the ILLIAC high-speed digital computer. Three systems were evaluated: an automatic system programmed to run without human intervention; an automatic system in which the officer could override the computer decisions at any time; and a manual system in which the computer did only routine vectoring of interceptors.

Although the pre-experiment hypothesis was that the man would tend to become overloaded with data when confronted by heavy raids and that the same number of targets would not degrade the performance of an automatic system, this did not prove to be true. Under heavy attacks the more automatic systems, although not overloaded, allowed more bombing target penetrations and accomplished fewer defensive kills than did the manual system. This happened because the man did *not* become overloaded and was able to perform much better than was predicted.

The man and the computer did not work well together when the machine was given any significant part in the decision-making. For one thing, the man learned through experience; the computer did not. For another, the man could often anticipate the "enemy's" moves; the computer could not. The man could make decisions on the basis of patterns or groups of attackers; the computer was programmed to treat each object separately.

Probably the most interesting conclusion is that the man is far more flexible than the machine. Compared to a computer, a man's ability to make absolute decisions and do fast computations is relatively poor. But in answer to the question of whether or not he could intercept before a raid reached the target, he could gamble in some circumstances and answer "maybe"; the machine

could only answer "yes" or "no." Thus the man might attempt an interception, sometimes with successful results, which initially appeared to be so unlikely that the computer would not even try.

Man's ability to weigh odds and to gamble gives him at present an advantage over the computer in this sort of test. Computers of the future will have to have the word "maybe" added to their vocabularies.

CIVIL ENGINEERING — THE OLD AND THE NEW

Civil engineering has changed since 1893, when Civil Engineering Hall was built at the University of Illinois. The old fireplaces and chimneys, the sculptured wooden staircases, the creaking wooden floors of the building have memories of the days when power was supplied by mules, men, and noisy steam engines, when roads had to be passable for wagons and the maximum speed was that of a fast horse. The memories are there, because Civil Engineering Hall is still the main building of the Department of Civil Engineering.

The faculty and students using the building, however, are more interested in the present and the future. They are using C. E. Hall not as a museum but as a place to learn the latest and best of a dynamic and progressive field of engineering.

Of course, Civil Engineering has space in several other buildings, too: 2 old houses, 2 Quonset huts, 1 converted house, one end of a temporary wooden shed, and "borrowed" space in Talbot Laboratory and the old surveying building. The only permanent structure the Department has all to itself is a small brick building used by the sanitary engineers.

Is this to be the Civil Engineering Department's only cornerstone for the future? Illinois voters will decide in the Universities Bond Issue election in November.

This space houses the largest daytime undergraduate enrollment in civil engineering in the country and the largest civil engineering graduate enrollment anywhere. Last year Civil Engineering had 612 undergraduate students and 245 graduate students. More are expected this year.

Twelve years ago, the Department requested a new building to meet expected development. No new building was built, and both undergraduate and graduate enrollment have more than doubled. They are asking for the same amount of space right now, to meet present needs.

Quantity is important to help meet the nation's growing need for civil engineers, but numbers alone are not the goal. The quality of the education given to our future civil engineers is of primary importance. The Civil Engineering Department has long been recognized as one of the best, and many members of the faculty are outstanding authorities in their specialties. A recent indication of quality at the undergraduate level came from the performance of nine students who participated in a National Science Foundation undergraduate research program. Of the nine projects, one won a national award in photogrammetry and three others have either been published or are awaiting publication in professional journals.

The lack of space has kept the Department from moving into new fields as rapidly as it should. The photogrammetry program, for example, is using a curtained-off portion of a classroom for its laboratory. New work should be started in air pollution and waste disposal, including radioactive wastes, but these subjects can't be fully developed without laboratory space, and there is none available. Highly significant work on structural dynamics, important in such matters as satellite and bomb shelter design, is handicapped by insufficient space. New developments in such other important areas as soil mechanics, hydraulics, and highways are hampered seriously for want of adequate facilities.

No figures on the demand for civil engineering graduates are available from the College's Placement Office — paradoxically because the demand is so great. Most of the recipients of graduate degrees are hired before they get to the Placement Office for interviews.

How well the Department of Civil Engineering will be able to do its job in the next few years depends to a considerable extent on the outcome of the Universities Bond Issue election next November 8. If the Universities Bond Issue is passed by the voters of Illinois, the State Assembly will have funds available from which the cost of adequate facilities for training civil engineers

may be appropriated. The Department of Civil Engineering at the University of Illinois can and will maintain its tradition of excellence, if it has adequate facilities. The Department can better teach twentieth century engineering if it is not restricted to a nineteenth century building.

NUCLEAR REACTOR BEGINS OPERATION

Experts predict that in the next 100 years we will need ten times more energy than the world's remaining fossil fuels can supply. This does not mean that the world's conventional fuel resources will be completely exhausted by 1970 since the rate of usage will increase more than tenfold during the next century. It does indicate the urgent need for fundamental research which will lead the efficient and widespread use of nuclear power facilities. Such research at the University of Illinois was given a big boost in August when the ILLINOIS TRIGA (educational and research) nuclear reactor was put into operation.

The ILLINOIS TRIGA was designed and constructed by General Atomic, a division of the General Dynamics Corporation. It is not designed to produce useful power but is a training and research reactor which operates at temperatures close to ordinary room temperature. It is licensed by the AEC for operation at 100 thermal kilowatts. With minor changes in shielding and cooling, the reactor is capable of much higher power levels.

This is the first above-ground reactor in the United States to use uranium-zirconium-hydride fuel. There are only 4½ pounds of U-235 in this fuel element, but it will generate power equivalent to the average electrical usage of 50 houses — and it will do so for 10 years!

Such fuel elements have the highly desirable property of limiting the reactivity of the reactor during sudden temperature increases. Thus, in addition to all the usual safety devices of control rods and monitoring, a TRIGA reactor is automatically self-limiting and self-protecting under any conceivable power excursion, so that completely safe operation is possible within convenient distance of other campus buildings.

Added safeguards for the ILLINOIS TRIGA are a windowless laboratory building and control of exhaust air. Though accessible, all beam ports are below outside ground level to avoid stray radiation.

The reactor tank, filled with purified water, is 6½ feet in diameter, 21 feet tall. During operation, fuel elements are visible from above. An adjacent 9 x 12 pool, also water protected, gives direct observation for radiation shielding studies. Four access ports through 7½ feet of concrete allow beams of neutrons from the core to be used for experiments located outside the reactor shield.

The reactor will be used not only for student training and graduate student thesis research, but also as a major research facility on campus. It will serve the state and the nation by supplying trained manpower through the advanced degree program in nuclear engineering. In addition, through its use in other courses and in "short courses," people in other fields will be trained in the handling of radioactivity, in isotope applications, and in tracer analysis of materials.

Results of research done with reactors like the ILLINOIS TRIGA will contribute to the development of nuclear fission power facilities, which will extend our energy-producing capabilities by another 100 years. Such fundamental efforts will also be instrumental in the development of the next step: the controlled thermonuclear fusion reaction, which will give us a cheap and nearly limitless supply of energy. It would not be an exaggeration to say that man's future depends upon this development.

Policies of the Nuclear Engineering Program are guided by an inter-departmental committee under the chairmanship of Professor Ross J. Martin. The members of this committee represent the interests of the various departments concerned and will be responsible for courses of instruction in reactor theory, design, and laboratory practice.

JOHNNY CAN'T DO MATH PROBLEMS EITHER

It seems quite probable that the well-known Johnny who couldn't read couldn't handle computations very well

Inside the University of Illinois nuclear reactor building Prof. Morvin Wyman (center) stands 12 feet above the reactor floor on the main concrete shield of the ILLINOIS TRIGA core. Prof. Ross J. Martin (top) stands on the platform from which fuel elements in operation may be observed. Prof. Martin heads the University interdepartmental nuclear engineering program; Prof. Wyman is chairman of the committee responsible for use of ILLINOIS TRIGA.

either — and for the same reason: the way he had been taught. In neither subject was he encouraged to think for himself. Instead he was filled with rules which often had little to do with reading or mathematics and which caused him to dislike both subjects. In other words, he wasn't primed; he was flooded.

Since 1952, the University of Illinois Committee on School Mathematics (UICSM), directed by Professor Max Beberman, has been working to develop a new curriculum for secondary schools. The UICSM is a joint committee of the Colleges of Education, Engineering, and Liberal Arts and Sciences.

The UICSM project seeks to remove the useless verbiage from the teaching of mathematics and replace it with encouragement to think creatively. To do this, members of the committee asked themselves such basic questions as: "What is a number?" "What is a variable?" What is an abstraction?" In answer to the last question, for example, they decided that *a* or *2* or a whole equation is *not* an abstraction. An abstraction is an entity which has no physical existence. The letter or numeral is simply a "concrete" instance of the abstraction to which it refers.

After defining such fundamental terms, the committee realized that most secondary school students (and some of their teachers) do not really understand the basic concepts of mathematics. The students were memorizing rules which they didn't understand to apply to concepts which they didn't understand either. The committee concluded that if Johnny could be made aware of mathematical abstractions before he began to manipulate the symbols which denoted them, he might be able to make sense out of the rules and discover some shortcuts for himself. If so, he would like mathematics and would do well in it.

With these principles in mind, the committee members started writing instruction materials, developing teaching methods, and training teachers for the new curriculum. Eight years of work have reinforced the beliefs of the people involved; and in July 1956 the Carnegie Corporation made the first bequest to the project of a grant that has since totaled more than a half-million dollars.

This year (1960-61) 120 schools across the nation are trying the UICSM program, and the eighth version of the instructional materials for the beginning course has been published. Through the Teacher Associateship program, each year 5 or 6 teachers spend a year working and studying in Urbana. In addition, summer workshops, personal consultations, and week-end conferences take place through the project center at 1208 West Springfield, Urbana.

Whether we are interested in Johnny as a son, a future engineer, a potential teacher, or just for his own sake, we may be certain of one thing: if he learns to read, write, *or* compute, it will not be because he has worked tediously with recipes. It will be because he has worked enthusiastically with ideas. That is what the UICSM project is trying to promote.

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ENGINEERING OUTLOOK
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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 1, NO. 6, OCTOBER 1960

THE UNIVERSITIES BOND ISSUE AND THE FUTURE FOR HIGHER EDUCATION IN ILLINOIS

On November 8 the voters of the State of Illinois will be asked to decide on the Universities Bond Issue, $195,000,000 for permanent improvements for the six state-owned universities in Illinois. The decision will affect higher education in the State for many years to come. Essentially, the choice is between having enough facilities to educate the increasing number of students who under present standards could and would attend college, or having to sharply restrict the number who will be given a college education.

Since Sputnik I, much has been said about more and better education. Now the voters of Illinois have a specific, concrete decision to make concerning higher education. They must decide if higher education requires additional support, and whether or not the Universities Bond Issue is the proper form for that support to take. Educators in Illinois hope that the voters will make this choice with the care and thoughtfulness that it deserves.

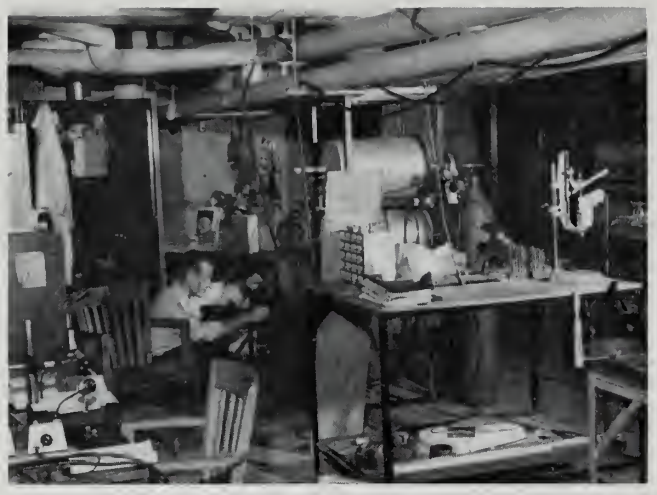
In a series of four articles since March, *Engineering Outlook* has presented some of the major space needs in the University of Illinois College of Engineering. The likelihood that these needs will be met will be much greater if the Universities Bond Issue passes. The first article told how the Physics Department for fifty years occupied a building in which laboratories finally had to be put in the attic and cellar, where students and researchers have to stoop under steam pipes or structural girders to move from one part of the laboratory to another. The article told how after fifty years the Physics Department was given half a building, and how the fate of the other half may depend heavily on the Universities Bond Issue.

The June *Outlook* told how the Electrical Engineering Department in 1945 requested a building to accommodate an undergraduate enrollment of 400. In 1949, they moved into a new building that represented *one-third* of the space requested for 400 students. The Department has had no further space added to its new building, even though enrollment in the spring of 1960 was 1,146 undergraduate students and 222 graduate students, about three times the enrollment which was ⅓ accommodated in 1949. The Universities Bond Issue will make funds possible for an addition to the Electrical Engineering Building.

The July issue of the *Outlook* told how the Aeronautical Engineering Department, with the largest undergraduate enrollment in aeronautical engineering in the United States, has never had a building of its own. Its offices are in the Transportation Building. Its laboratories are in the old Locomotive Laboratory and the old Machine Tool Laboratory, both buildings "inherited" from other departments after they were outmoded for their original purposes. Two Quonset huts at the University airport, six miles from the campus, are also used for laboratory space because equivalent space is not available on the campus. With such facilities the Aeronautical Engineering Department has the task of educating engineers to design and develop the aircraft and spacecraft so important to this nation's future. The passage of the Universities Bond Issue would bring a new Aeronautical Engineering Building nearer to realization.

The Civil Engineering Department, one of the largest in this field, is training its 612 undergraduate students and its 245 graduate students in Civil Engineering Hall, built in 1898. This is supplemented by space in 2 old houses, 2 Quonset huts, 1 converted house, one end of a temporary wooden shed, and "borrowed" space in Talbot Laboratory and the old Surveying Building. The only permanent structure occupied only by Civil Engineering is a small laboratory for sanitary engineering. Passage of the Universities Bond Issue would brighten hopes for a new Civil Engineering Building.

These are only some of the more pressing needs of the College of Engineering. Virtually every department is inadequately housed. Some are in the University's building plans for new buildings or additions to old, and some hope to get more space in old buildings as other departments move into new quarters. Funds in the Universities



Shortage af space in the ald Physics Labaratary Building has farced the use of basement areas where research apparatus has ta be fitted in amang the steam pipes.

Bond Issue are not specifically allocated, but the needs outlined here have been recognized by the University as urgent. Passage of the Universities Bond Issue will bring these buildings much nearer to reality.

The University of Illinois College of Engineering has a high reputation among engineering schools. Through the years it has supplied Illinois and the nation with hundreds of well-trained and sorely needed engineers in many fields. More men with this kind and quality of training will be needed in the future. In fact, engineering enrollment at the University of Illinois has more than doubled since 1951 and the number of young people wanting engineering training will continue to grow. The crucial question is whether or not the voters will provide the facilities for training all the young people who have the desire and ability to be engineers, so that they can realize their own amibitions and meet the nation's need. November 8 is the time of decision.

EXPERIENCE BOWS TO THEORY — ALMOST

The interplay between experience and theory seems to take greater proportions each time an old machine component is redesigned. For example, recent Diesel engines, with their increased speeds and higher cylinder pressures, have shown older Diesel connecting rod designs to be lacking in reliability. An investigation of this problem was begun in 1958 under the direction of Professor E. I. Radzimovsky of the Mechanical Engineering Department.

It was obvious at the beginning of the study that increasing the cross-section of the connecting rod would increase its strength but would also increase the inertial forces, reducing the reliability even more. Therefore, "time proven" design features would have to be succeeded by new ideas if the resultant design was to fit present-day requirements. Carl S. Larson, a graduate assistant in Mechanical Engineering, has undertaken the study of important factors in connecting rod design such as rod geometry, bearing clearance and bearing cap rigidity. He is concentrating his work on the components of the rod assembly which might affect its reliability.

Although this project is sponsored only by the Mechanical Engineering Department and is somewhat limited in funds, it was necessary to build a machine to test the theories which were developed. A special test machine which would simulate the load conditions in an operating Diesel engine was designed, with important contributions being made by Professor D. F. Offner. A number of graduate students also worked on this project as part of their educational program.

The machine is now partly completed, but a great deal of work (completing the design and construction, calibration, and instrumentation) is still ahead before it is put into operation.

Regardless of initial plans, many problems arose in the design of the machine which could only be solved by the use of knowledge gained through experience — neither theory nor practical knowledge could survive alone. But the combination of empirical and theoretical methods is expected to bring forth a solution to the problem.

SELF HELP THROUGH ENGINEERING EDUCATION

The United States Government has recognized that the best way to fulfill one of the many responsibilities of world leadership is to help other countries raise their own standards of living. The International Cooperation Administration (I.C.A.) is the branch of government involved in this endeavor, and the University of Illinois is making a major effort to assist the I.C.A. in various educational programs for India. The College of Engineering has participated in this program since 1953.

There are two engineering programs of educational aid currently in operation at the University of Illinois, in addition to an extensive program in the field of agriculture. Under the Engineering Education Program, faculty members from various Indian engineering colleges visit the University to receive graduate training in their respective fields of engineering, as well as some instruction in undergraduate teaching methods, curriculum content, and college administration. These men, each of whom spends one year or more at the University, are all committed to teach engineering in India after their training is completed. Since 1958, 70 of them have been or are in this program, which is currently under the guidance of Professor T. W. Price of the Mechanical Engineering Department.

The other program has a longer history. Since 1954 the University has played an important role in the development of the Indian Institute of Technology in Kharagpur, West Bengal. Ten U. of I. engineering professors have helped with the development of this institution. In addition, one group just left recently for Kharagpur. It consisted of Julian Fellows and Francis Seyfarth, both Professors of Mechanical Engineering, Willis Emery, Professor of Electrical Engineering, and Henry Langhaar, Professor of Theoretical and Applied Mechanics.

The Indian Institute of Technology has been helped in other ways through this program. Twenty-three of the Institute faculty have been sent to Illinois for advanced training, and about three-quarters of a million dollars worth of equipment, purchased by the University with I.C.A. funds, has been supplied to the Institute. This program is under the supervision of Professor Ralph C. Hay, campus Coordinator of the University's International Cooperation Programs.

These programs of aid to India, completely financed by I.C.A., are excellent examples of the work done cooperatively by the government and the universities to aid other peoples through engineering education.

TEACHING TOMORROW'S TEACHERS

As enrollments in engineering classes increase each year, a problem almost as serious as the current need for engineers shows itself: the need for engineering teachers. Because of the University's efforts to solve this problem and the farsightedness of some industry foundations, there will be 48 graduate students on the engineering campus this fall working toward a career in engineering teaching through four separate programs.

The Illinois Intern Program, sponsored by a Ford Foundation grant, will allow 20 of these students to continue toward their goals. This group is made up of men with B.S. degrees who will spend four semesters in the program. In addition to course work, each intern attends a series of seminars on widely varied subjects and is given actual teaching experience in the classroom. In 1961 an additional ten men will be added to the present group of 20 interns.

Twenty-four of the 48 are sponsored by a separate Ford Foundation Fellowship-Loan Program. These men all have M.S. degrees, have had previous teaching experience, and are working toward Ph.D.'s.

The Alfred P. Sloan Foundation has established fellow-

This map shows where the engineering teacher-trainees received their bachelor degrees before entering their present programs at the University of Illinois.

ships for three of the teacher-trainees, all of whom have B.S. degrees and need advanced work to prepare them for teaching positions.

The remaining man, a Ph.D. candidate, is on a fellowship established by Standard Oil Foundation.

Students come from colleges all over the United States and Canada to participate in these programs. In fact, Professor Seichi Konzo of the Mechanical and Industrial Engineering Department points out that there is a long list of applicants awaiting an opportunity. Professor Konzo is not only the coordinator of the Illinois Intern Program, but also chairman of the reviewing committee which selects applicants for the other three programs. The other members of this committee are Professor Wendell E. Miller (Electrical Engineering), Professor C. P. Siess (Civil Engineering), and Professor J. O. Smith (Theoretical and Applied Mechanics).

Admission requirements are a high scholastic record, letters of recommendation from engineering instructors, and a strong interest in the engineering teaching profession. Course work involves meeting regular language requirements for the Ph.D. degree, taking advanced engineering courses, and fulfilling research requirements for the thesis.

These programs will have to be expanded or supplemented by other programs if the ever-growing demand for engineers is to be met. Obviously, an adequate supply of well-trained engineers cannot be furnished without an adequate number of well-qualified engineering teachers to train them.

LICENSES COMING AND GOING

There will not be any more seven-character combinations on Illinois vehicle license plates. Starting with the 1961 registrations, Illinois plates will carry a straight numerical sequence from 1 through 999,999, and will then switch to two letters followed by four numerals, such as AB 1234.

This change was based on recommendations made by traffic engineers of the University of Illinois. A study in cooperation with the office of Secretary of State was begun in 1958 to determine the proper functions of license plates, what information should be placed on plates, and the best methods of presenting this information. The study was directed by Professor John Baerwald.

The final report has just been published as Engineering Experiment Station Bulletin 457, *The Functions and Design of Motor Vehicle License Plates,* by John Baerwald, Delbert Karmeier, and Gordon Herrington. It contains 61 pages, 31 figures, and 33 tables.

The bulletin contains chapters on such topics as the functions of motor vehicle license plates, the vehicle registration number, the design of motor vehicle license plates, and the design of reflectorized license plates. It is available from the Engineering Publications Office at the cost of $1.25 per copy.

Recent Publications of the Engineering Experiment Station

Bulletin 457, *The Functions and Design of Motor Vehicle License Plates,* by John Baerwald, Delbert Karmeier, and Gordon Herrington, 61 pp., $1.25 per copy.

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ENGINEERING OUTLOOK
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 1, NO. 7, NOVEMBER 1960

ALUMNI JOIN IN REACTOR DEDICATION

On October 21 the University officially dedicated the new TRIGA MARK II nuclear reactor. Members of the Engineering Alumni Committee, on campus for their annual meeting, also attended the dedication for a look at one of the latest educational and research tools at the University. After the dedication ceremonies, Atomic Energy Commission officials and other distinguished guests were invited to attend the Alumni Committee meetings taking place on the evening of the 21st and throughout the following morning.

The reactor, the first above-ground type in the United States to use uranium-zirconium-hydride fuel elements, was open to inspection throughout both days. Alumni Committee members and the guests attending the reactor dedication toured the reactor facilities. Guides described the reactor's place in the Engineering Experiment Station's research program and in the College's graduate degree program in Nuclear Engineering.

The Alumni Committee was formed in 1952 to serve as a liaison between the College and Illinois high schools. The committee, made up of graduates of the U. of I. College of Engineering, has grown from its original 41 to 137 members, serving high schools in many regions of Illinois and adjoining states. The men are all situated in industry or in private consulting practice.

The Engineering Alumni Committee is not a student recruiting agency, but rather a group which informs high school students of the opportunities of an engineering career. The men serve as a source of authority for the field of engineering and are often called upon by high school principals to speak to the students during Career Day programs. Upon request the men also counsel students individually.

The committee is directed by an advisory board of seven men: Frank H. Beinhauer, chairman, Decatur; Dean C. Broughton, Milwaukee; Ralph E. Campbell, Crystal Lake; Charles A. Davis, Moline; F. M. Rich, East Chicago, Indiana; J. G. Ryan, Wood River; and Thomas D. Wofford, Chicago.

Information and aid are supplied to this committee through W. L. Everitt, Dean of the College of Engineering. Requests for further information about this committee may be addressed to Dean Everitt, 106 Civil Engineering Hall, Urbana, Illinois.

U. OF I. PROFESSORS IN INTERNATIONAL ELITE

The basic nature of much of the research program in the College of Engineering was strikingly illustrated recently by invitations to two engineering professors to the Symposium on Basic Sciences in France and the United States, held in October in New York City. Dr. Ven Te Chow of Civil Engineering and Dr. James M. Robertson of Theoretical and Applied Mechanics participated in the Symposium of 100 leading scientists from universities, governments, and industrial laboratories in France and the United States.

The Symposium was sponsored by the Sloan Foundation and the French Government to provide an exchange of ideas among scientists from several fields.

Dr. Chow is conducting research currently in hydrology and hydromechanics. Some of his projects include tornado studies, highway drainage problems, surface runoff factors, and the theory of gradually varied flow.

Dr. Robertson, conducting research in fluid mechanics, is concerned currently with the behavior of bodies passing from water to air as in the case of underwater launching of missiles. Also he is studying the turbulent boundary layer theory in regard to lubricant flow phenomena.

The Alfred P. Sloan Foundation, co-sponsor of the Symposium, includes among its purposes the support of research and education in the physical sciences. The foundation also maintains an extensive undergraduate scholarship program.

QUALITY CONTROL IN ENGINEERING EDUCATION

Much has been said recently about the need for greater numbers of trained engineers, but the drive for quantity has not made educators at the University of Illinois lose sight of the need for quality. One phase of the College

The rodiooctive core of the College af Engineering's new Illinois TRIGA MARK II nuclear reactar is visible fram obave through 16 feet af demineralized water. Reactor Supervisor Gerald Beck (left) and Prafessor D. F. Hang are shown here checking radiation detectian devices. Control rods can be seen extending from the left downward into the care. The Nucleor Reactar Labaratory was dedicated an October 21 in ceremonies and symposia held thraughaut the day an the Urbana campus. The dedicatian was held in conjunction with the annuol meeting of the College's Engineering Alumni Committee.

of Engineering's effort to get the highest quality is its Honors Program.

Of 5080 entering freshmen this fall on the Urbana campus, 192 were in the Edmund J. James Scholar Program, and of these, 34 are in the College of Engineering. Electrical Engineering leads with 11 students and Engineering Physics is second with 8. The remaining students are well distributed through 6 other departments in the College, with 3 still unspecified as to field of engineering. There are 301 students in the James Scholar Program at all levels, of which 46 are in Engineering.

The James Scholar Program was initiated by the University in September, 1959, to recognize and encourage outstanding scholarship. The Program operates in conjunction with undergraduate honors programs in the various colleges and schools of the University. The Honors Program in Engineering began in September 1960, and has already achieved an important share in the total University effort.

The Program is designed to provide the superior student with greater opportunities and flexibility than possible in the normal curriculum, and to give him a climate for deepened intellectual development. Minimum requirements for freshmen entering the Honors Program in Engineering include admission to the University as a James Scholar. Honors students will be expected to maintain a grade point average of 4.5 (B+).

Students in the Honors Program are assigned to special advisors and encouraged to satisfy course requirements by proficiency examinations or to go directly to advanced courses when advisable. Special sections have been established for them in some courses. For upperclassmen there will be such activities as special projects and seminars.

The Honors Program in the College of Engineering is directed by a faculty committee under the chairmanship of Professor A. I. Ormsbee of the Department of Aeronautical Engineering. Other members of the committee are Professors E. L. Broghamer, E. D. Ebert, C. D. Hendricks, R. E. Miller, D. R. Opperman, D. D. Perlmutter, Mete Sozen, F. V. Tooley, Albert Wattenberg, C. A. Wert, and R. R. Yoerger, representing the various departments in the College.

At a time when our civilization requires the highest possible development of "brainpower," educational institutions have an important obligation to their superior students. In the University of Illinois College of Engineering, this obligation is being met through the Edmund J. James Scholar Program and the College's associated Honors Program.

ENROLLMENT STATISTICS

Final College of Engineering enrollment figures for this semester have been tabulated. By curricula, they are:

AERONAUTICAL ENGINEERING	378
AGRICULTURAL ENGINEERING	74
CERAMIC ENGINEERING	98
CIVIL ENGINEERING	612
ELECTRICAL ENGINEERING	1178
ENGINEERING MECHANICS	60
ENGINEERING PHYSICS	230
GENERAL ENGINEERING	348
INDUSTRIAL ENGINEERING	121
MECHANICAL ENGINEERING	604
METALLURGICAL ENGINEERING	87
MINING ENGINEERING	37
Total	3827

Reflecting the general trend of enrollment increases in the fields of study in science and engineering, the number of beginning freshmen is 15 per cent higher than the number entering at this time last year.

SHORT COURSE ON WELDING ENGINEERING

The first Biennial Short Course on Welding Engineering will be held on the University of Illinois campus December 5-8. The Short Course is being presented through the Division of Engineering Extension. It will be conducted by the Departments of Civil Engineering, Mechanical and Industrial Engineering, and Mining and

Metallurgical Engineering, in cooperation with the American Welding Society.

Besides 12 speakers from the faculties of the departments conducting the Short Course, there will be 15 speakers from industry and research organizations.

A registration fee of $65 will be charged for the four-day meeting. This fee includes text materials, a copy of the short course proceedings, four scheduled luncheons and a banquet, but not lodging or other meals. Advanced registration is recommended, and this can include reservations for housing during the Short Course.

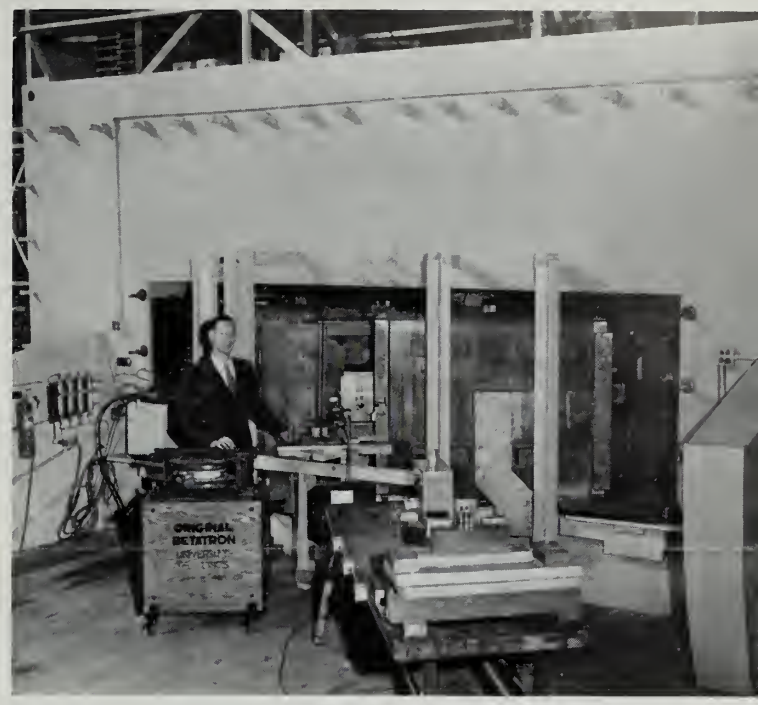
Additional information and reservation and registration forms may be obtained from the Supervisor of Engineering Extension, 116d Illini Hall, Champaign, Illinois.

BRIDGING THE MICROWAVE GAP

The detectable waves in the electromagnetic spectrum, in order of increasing frequency (decreasing wavelengths), are radio waves, television signals, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and the family of cosmic rays. Between microwaves and infrared radiation, roughly in the wavelength ranges of 1/10 to 1 millimeter, there is a gap that contains waves which have not been generated in the laboratory. These waves are commonly referred to as ultramicrowaves or submillimeter waves.

The Ultramicrowave Group at the University of Illinois, headed by Dr. Paul D. Coleman, has spent the last ten years trying to bridge this gap by building apparatus to generate, propagate, and receive these high-frequency waves. They have aided in narrowing the gap from its 1950 frontier of 4 millimeters to its present position through the development of a complete set of 2 millimeter components, now produced for the open market

A set of 2.14 to 1.36 millimeter wave components using 0.051 x 0.0255 inch ID copper waveguides.



Professar D. W. Kerst stands by twa af his creatians, the 2.3-million electron volt betotran which is being donoted os a permonent disploy to the Smithsanian Institutian and the mare recent 340-MEV betotron, which is still a major reseorch taal at the University.

by a New York firm. These components, including antennas, waveguides, terminations, tuners, and detectors, are the smallest commercially available microwave components in the world.

One gets a good idea of the extremely small size of these components from the largest inside dimension of the waveguide cross-section, which is .080 of an inch. A waveguide, as its name suggests, is a hollow rectangular tube which directs the microwave signal to its desired destination. Twenty years ago, 108 mm. waveguides used in some radar systems were considered quite small, but those developed at the University are more than 50 times smaller!

Today it is possible to produce microwaves of 2 mm. wavelength in the laboratory, although not in the quantities of power desired. No reliable way of producing waves in the submillimeter range, 1/10 to 1 mm., has yet been found. Many people feel that electron tubes have reached their practical frequency limit, and that an entirely new set of techniques will be required for further advances.

In fact, the members of the University of Illinois group have given up conventional approaches to wave production and have experimented with optical, solid state, and electron beam interaction techniques. More recently, using megavolt electronics techniques with Cerenkov radiators, they have had promising results which were

described in the September 1960 issue of the *Journal of Applied Physics.*

Ultramicrowaves will have many beneficial uses when the problem is finally solved. They are needed to probe the interactions of electrons in plasma jets, primarily because plasmas are opaque for frequencies below the plasma frequency. They will be useful for analyzing the atomic reactions in nuclear reactors; for communications between space vehicles because of their low interference noise characteristics, their high directivity with modest size and power, and their inability to penetrate the atmosphere (which would make such signals undectable from earth); and for the study of microorganisms, which change from their ordinary random orientation to an alignment across the lines of force in a microwave field.

Workers in the Ultramicrowave Group are seeking to find an answer to their problem in almost every area of physics and electronics. The gap in the spectrum is being narrowed year by year, but only its final bridging will provide answers to the many speculations about the real nature of ultramicrowaves.

WORLD'S FIRST BETATRON TO SMITHSONIAN

The world's first betatron, an atom-smashing electron accelerator invented at the University of Illinois in 1940 by Professor D. W. Kerst, is being given to the Smithsonian Institution for permanent display.

This first pioneering device which produced 2.3-million electron volts of energy was requested by the Institution for exhibition in the Hall of Electricity of the new U. S. National Museum building in Washington, D. C.

Professor Kerst built three other betatrons which are still in use at the University. A 24-million volt machine, completed in 1941, is the prototype of many now used as X-ray or electron beam sources by medicine and industry. The 80-million volt machine was built in 1948 as a model for the University's 340-million volt betatron, the world's largest, completed in 1950. University of Illinois physicists use the betatrons primarily for research in nuclear physics.

Professor Kerst built his first betatron in the face of failure by others who had tried for years to build a machine which could produce high-energy electrons by means of a magnetic field. It went into operation July 15, 1940. It is about the size of two typewriters side by side, in contrast to multi-million volt conventional X-ray machines, which are as big as automobiles.

The U. of I. 340-million volt betatron became operative February 15, 1950. The science of designing and building betatrons had developed so much during the decade that if the big betatron could be scaled down on a volt for volume basis, 2.3-million volt energy rays would come from a machine the size of a penny matchbox!

Professor Kerst, born in Galena, Illinois, grew up and attended schools in Wauwatosa, Wisconsin, and received bachelor's and doctorate degrees from the University of Wisconsin. He joined the University of Illinois staff in 1938. In 1957 he joined the General Dynamics Corporation as the leader of a $10-million controlled thermonuclear research project.

Among the honors he has received for the invention and development of the betatron are a fellowship in the American Physical Society, membership in the National Academy of Sciences, the Comstock Prize of the National Academy, and the Scott Award of the Franklin Institute.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 1, NO. 8, DECEMBER 1960

THE CONSTRUCTION ENGINEERING CURRICULUM

You are a contractor who is interested in bidding on a highway job which requires 100,000 tons of grade 7 gravel. Would you like to be able to obtain this gravel for 50 per cent of what you might be paving now?

You are a contractor who is constructing a building. Would you like to be able to know (1) on what date you should order each of your materials; (2) what dates you should insist upon for their deliveries; (3) the starting and finishing dates of each of the critical jobs in the construction sequence; and (4) how much leeway exists in each of the noncritical jobs — so you could construct the building for 75 per cent of what it might cost you now?

You are a contractor who is interested in bidding on some earthwork. Would you like to be able to determine (1) how long each piece of your available equipment should be used on which operations; (2) which pieces of equipment you should rent; and (3) how long each piece of rented equipment should be used on which operations — so you could do the job at minimum cost to you?

If your answer to any of these questions is "yes," you should be interested in a unique educational program at the University of Illinois which is headed by Professor L. R. Shaffer and administered by the Construction Engineering Division of the Civil Engineering Department. These questions are typical of the sort that are asked in this program, which is dedicated to scientific studies of scheduling, planning, and the selection of men, materials, and equipment that will allow the contractor to perform his work with maximum efficiency and profit.

A student who majors in construction engineering will take all the regularly required courses in civil engineering plus five courses in his major field. These courses are Construction and Engineering Economy, Construction Productivity, Construction Planning, Construction Cost Estimates and Analyses, and Engineering Law. They are designed to teach the student how to apply fundamental principles of economics, mathematics, and the physical sciences to the evaluation of the factors which underlie all construction work. A certain amount of stress is placed on the limitations of such applications. These principles cannot be used as a substitute for the contractor's good judgment and the knowledge he has gained from experience. They certainly can, however, provide numerical results which will aid him in making decisions.

Education and research work such as that being done by the U. of I. Construction Engineering Program will some day eliminate much of the guesswork which now plagues the contractor on the more complex construction sequences — as well as furnish graduates who will have practical experience and background in solving such problems. This program will provide the sort of knowledge that has been sorely needed by construction contractors since Marcus Appius lost his toga in CDXIX B.C. contracting on the first road that led to Rome.

SANITARY ENGINEERING CONFERENCE

When Leeuwenhoek reported seeing "wee beastics" through his new microscope in 1683, he didn't know what he was helping to start. From nearly three centuries away, you might say he deserves some credit for the Third Sanitary Engineering Conference at the University of Illinois. The Conference title, "Disinfection and Chemical Oxidation in Water and Waste Treatment," indicates that Leeuwenhoek's wee beasties, and perhaps some he didn't see, will be important topics.

The Conference will be held January 31-February 1, 1961, on the University of Illinois campus in Urbana. It will be sponsored jointly by the Division of Sanitary Engineering of the Illinois Department of Public Health, and the Department of Civil Engineering of the University.

A distinguished group of nineteen speakers has been arranged for the two-day meeting, including men from industry, federal and state agencies, and the faculty of the University. Some of these speakers are E. J. Laubusch, Technical Manager for the Chlorine Institute in New York City; R. S. Ingols, Director of the School of Applied Biology, Georgia Institute of Technology; and R. J. Brink, Director of Industrial Waste Control,

Buick Motor Division in Flint, Michigan. The featured speaker of the two-day program will be W. J. Orchard, Director-Consultant for the Wallace and Tiernan Company of Newark, New Jersey. He will speak at the dinner on Tuesday, January 31.

The registration fee for the Conference is $15. This fee does not include meals and lodging. Housing information for the Conference is provided with the program on inquiry.

Copies of the complete program and further information concerning registration, housing, and other details can be obtained from Professor Ben B. Ewing, Department of Civil Engineering, University of Illinois, Urbana, or from C. W. Klassen, Chief Sanitary Engineer, Department of Public Health, Springfield, Illinois.

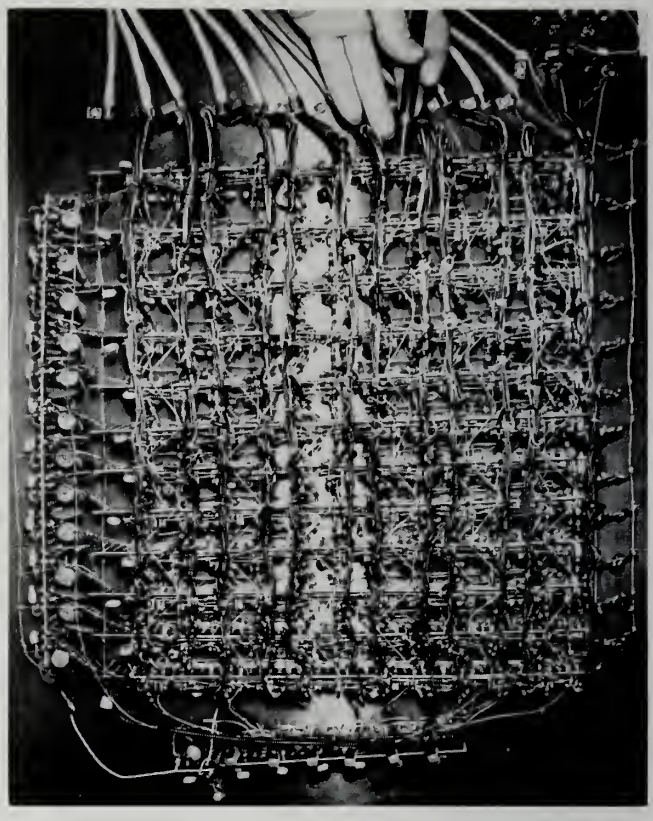
BIOLOGICAL COMPUTERS

Most visitors to the University of Illinois Biological Computer Laboratory are probably surprised not to find a big box labeled *Biological Computer.* Instead they are told that such computers do not come in boxes yet, but that examples can be found almost everywhere, crawling, walking, or jumping around on two, four, six, or more legs: they are the living creatures which respond in a well-ordered manner to the stimuli of an environment which itself has order and structure.

An uninitiated visitor, protesting that cockroaches have never been caught compiling logarithmic tables, will soon be told that, nevertheless, they must apply some computational principles in order to survive. He may remember that attempts to step on one of these creatures usually ends in failure; the roach escapes because it has figured out the man's pattern of movement in time to move out of the way.

Today many fascinating computational principles which are the basis for the complex activities of living animals are known. These principles should not be confused with the computational principles used in modern digital or analog computers — the ones which *are* in big boxes. Living systems have to respond quickly and reliably to complex stimuli in spite of the fact that their ultimate information handling component — the nerve cell — is slow and unreliable. Existent electronic computers, on the other hand, perform relatively simple operations — additions, multiplications, etc. — with extremely fast and ultra-reliable electronic components. This handicap of the living creature is, however, more than compensated by the versatility of its information processing networks.

The people in the Biological Computer Laboratory, under Professor Heinz von Foerster, are interested in analyzing and synthesizing the structure of such networks through electronic "hardware" — not in an attempt to imitate the biological systems, but in order to build electronic devices which exhibit the adaptiveness and self-organization of a living animal.



The computational circuitry of the Numo-Rete, a biological computer property filter which performs a function similar to that of the eye of a living organism.

Just as living organisms adapt themselves to their environments, biological computers can be made to do the same thing in much the same manner. Thus the living organism, through its sense organs and nervous system, selects ordered events from the chaotic mass of information in its surroundings, and the biological computer, depending upon its design, can have sensor units and computational networks which are sensitive only to certain intensities of light, certain frequencies of sound, certain pressures, etc. Devices which perform such selective functions are called "property filters."

One such property filter which has been constructed at the University is called the "Numa-Rete." It is an array of photocells which are connected to an appropriate network so that it "sees" at one glimpse the number of disconnected objects in the visual field of its retina. This experimental property filter will instantly recognize "7-ness" from "15-ness" as a man can instantly distinguish between "green-ness" and "red-ness."

A visitor to the laboratory will also find other networks in operation. There is one which "learns" the rules of simple games without being told what these rules consist of. He will discover a variety of complex components, so-called "artificial neurons," which are able to

learn, to forget, and spontaneously become active when threatened with isolation. He will see networks under construction which can attempt self-repair and others which can recognize the size and shape of geometrical objects.

He will come to realize that some of the artificial networks in the Biological Computer Lab exhibit the same sort of curiosity about their surroundings that he is showing toward them. We predict that by the time he leaves he will certainly appreciate the fascinating aspects of this novel area which lies between biology, electronics, physiology, and psychology.

BEING COMPETITIVE THROUGH PLANNING

Winter is a good time to stir up interest in home heating, but for hydronic heating contractors it is a "hot" subject any time. In this highly competitive field, the contractor who keeps up with the latest information can best serve his customers and conduct a successful business. To help bring this information to contractors, the University of Illinois and the Institute of Boiler and Radiator Manufacturers are jointly sponsoring their Thirteenth Short Course on Hydronic Heating and Cooling Systems.

The name of this year's short course is "Fundamentals of Being Competitive Through Managerial and Technical Planning," a course designed for hydronic heating contractors, specifically owners and managers. The course will be held January 30-February 2, 1961, on the Urbana campus. It is a supplement to the I=B=R Hydronic Heating School and is not a substitute for it. Meeting today's competition requires careful planning and both this course and the I=B=R School are designed to assist heating contractors to attain that objective.

Technical sessions in the four-day program will cover such topics as heating and load calculations, bidding, and selection of equipment. They will include a tour of research facilities at the University. Sessions on management will consider business policies and growth, organization, estimating practices in relation to direct and overhead costs, advertising and promotion, and research for improved future technology.

The registration fee for the Short Course is $40 per person. This fee includes text materials but not food and lodging. Additional information, preliminary programs, and registration and housing forms are available on request from the Supervisor of Engineering Extension, 116D Illini Hall, Champaign, Illinois.

HYDRONIC HEATING AND COOLING RESEARCH SUMMARY

Twenty years of research in hydronic heating and cooling have been very briefly summarized in a new publication by the Mechanical Engineering Department, "Summary Cooperative Research on Hydronic Heating and Cooling."

The cooperative research program in steam and water heating and summer cooling has been carried on at the University of Illinois since 1940. The work is under a contract between the Engineering Experiment Station and the Institute of Boiler and Radiator Manufacturers. It is now under the direction of Professor Warren Harris of the Department of Mechanical Engineering.

The summary outlines investigations undertaken and the results obtained, with a list of publications containing detailed reports of these results. The material is divided into sections on winter heating, summer air conditioning, heating and air conditioning loads, domestic hot water, and snow melting. In outline form and written for technical people actually in the field, this new publication, Research Series I=B=R-4, is available in limited quantities upon request to the Mechanical Engineering Department, University of Illinois, Urbana, Illinois.

One of the I=B=R Research Homes at the University of Illinois used to study steam and hot-water heating equipment. This is one of the facilities the attendees of the Thirteenth Short Course on Hydronic Heating and Cooling Systems will be shown.

CHANGES OF ADDRESS

Sometimes success creates almost as many problems as it solves. This has been the case with *Engineering Outlook*. With circulation presently running over 12,000 copies per issue and increasing constantly, keeping addresses up to date has become difficult. One solution to this problem would be for subscribers who are specifying a change of address to also send the printed address from a back issue or an exact copy of it. This would be a great help.

Subscribers to *Engineering Outlook* include private individuals, secondary schools, and major industries throughout the State of Illinois. It is also sent on a reciprocal basis to other universities, both in the U.S. and throughout the world. Designed to keep industry and the public informed about research being done at the University, new scientific techniques, and the latest facts about engineering education, it is also the Engineering College's sole vehicle for the public announcement of new publications and reports.

Any remarks, questions, or suggestions can be addressed to: Engineering Outlook Editors, 114 Civil Engineering Hall, University of Illinois, Urbana. Such comments are appreciated because of our continual desire to improve the paper and make it something more than just another piece of mail for your desk. We realize that there is already enough of this sort!

STUDENT ENGINEERING MAGAZINE HONORED

Two first place trophies were awarded to the U. of I. student engineering publication, *Illinois Technograph*, this fall at the national convention of the Engineering College Magazines Associated.

The *Technograph* received the awards for best covers for the entire year and best single cover. Barbara Polan, a senior in art, designed the prize-winning covers. Honorable mention went to a nontechnical article, "Wanted: Engineers Who Can Write," by Verne Moberg, a part-time technical editor and senior last year in LAS.

The *Technograph*, published since 1885, is written, edited, and managed solely by students. *Technograph* staff members gain valuable experience working together to meet deadlines and to build the magazine's circulation. Copies are sent not only to college students but also to about 700 Illinois high schools to stimulate interest in the field of engineering.

The articles, ranging from technical papers to student essays, are all aimed at the engineer and engineering student. The chief purpose of the magazine is to inform the college student of recent technical developments both at the University and in industry. However, many industries also subscribe to the publication in order to keep in touch with the trends in engineering education and research at the University.

Subscriptions are available at $1.50 per year by writing to *Technograph*, 215 Civil Engineering Hall, Urbana, Illinois.

Recent Publications of the Engineering Experiment Station

A Summary of Engineering Research 1959, 146 pp., free of charge.

Summary Cooperative Research on Hydronic Heating and Cooling, 30 pp., free of charge.

Bulletin 457, *The Functions and Design of Motor Vehicle License Plates*, by John Baerwald, Delbert Karmeier, and Gordon Herrington, 61 pp., $1.25 per copy.

Circular 67, *Manual of Current Practice for Design, Construction, and Maintenance of Soil-Aggregate Roads*, by Eugene Y. Huang, 145 pp., $1.00 per copy.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 2, NO. 1, JANUARY 1961

HIGHWAY AND TRAFFIC ENGINEERING CONFERENCES

America is a nation of roads and road builders. More than 40,000 miles of new superhighways are scheduled for completion in the next few years. In the state of Illinois alone there are nearly 3,000 agencies which are concerned with highway and traffic engineering, construction, and law enforcement. The University of Illinois has long served as a research center and coordinating agency for these groups; in fact, the U. of I. Civil Engineering Department has been sponsoring highway engineering conferences since 1914!

The 47th annual Illinois Highway Engineering Conference is being held on the University campus February 28 through March 2. Some of the major topics to be discussed are *Economic Forecasts, Quality Control of Concrete, Medians for Divided Highways,* and *Relationships Between Urban Planning and Highway Planning.* Professor Ellis Danner, 300 Civil Engineering Hall, is the Highway Conference Director.

The 13th annual Illinois Traffic Engineering Conference is being held on March 2 and 3. The major topics in this conference will be *Community Planning and Traffic, Traffic Engineering Management Problems, Traffic Engineering in Medium and Small Communities,* and *Traffic Topics of General Interest.* Professor John Baerwald, 404 Civil Engineering Hall, is the Traffic Conference Director.

Advance registrations are available for either of these conferences through Professor Danner or Professor Baerwald. A registration fee of $2.00 per person is charged, which entitles attendance at either or both conferences. This fee, which should not be mailed with advance registrations, is payable at the conference sign-in desks. All interested persons are invited to correspond with the conference directors for further information, advance registration forms, or conference programs.

SUMMER PROGRAM FOR TECHNICAL INSTITUTE TEACHERS

Technical institute and junior college teachers in mathematics, electronics, and machine design will have an eight-week summer institute available to them at the University of Illinois next June 19 through August 12. The program is sponsored by the National Science Foundation, and financial assistance for all participants will be available in the form of stipends, dependent allowances, and travel allowances.

This summer institute is the direct outgrowth of the work of the Technical Institute Curriculum Advisory Committee, a University group which has been working with the Illinois State Office of Public Instruction to promote the establishment of a number of technical institutes throughout the state. This committee, made up of members of the University's College of Education and College of Engineering, has advocated this program to provide training in depth of subject matter for people who are now teaching in such existing institutes and may be instrumental in the establishment of new ones.

Members of the committee feel that one of the best solutions for the current shortage of engineers is the training of ample numbers of engineering technicians. The technician, requiring much less formal training than the engineer, can allow the engineer more time to make use of his abilities at the highest professional level. The committee members estimate that for the most efficient use of engineering manpower there would be three technicians for every engineer; the present ratio across the country is only one technician for each engineer.

In addition to the *Engineering Mathematics Course, Drafting and Mechanical Design Technology Course,* and *Electronics Engineering Problem Course,* there will be a series of seminars on the philosophy of technical institute education and the place of the technician on the engineering manpower team. Although there will be no tuition fees, there will be supplementary fees totaling $9.00 and room and board expenses. The University will reserve housing for single persons or families upon request. Further information, housing forms, and applications are available from:

Professor J. S. Dobrovolny
115 Transportation Building
University of Illinois
Urbana, Illinois

The deadline for applications is February 15, 1961.

KEEPING OUTWARD WITH THE TIMES

Current news articles suggest that the direction of the day for aeronautical engineers is faster and higher. Speeds reaching and even exceeding earth's escape velocity are common topics of conversation these days, and altitudes which might better be referred to as "outward" rather than upward appear in the news with regularity.

These are certainly more than just topics of conversation in the University's Aeronautical Engineering Department. This is well shown by recently completed modifications to the Department's shock tube. This device is now able to propel a shock wave through gas at velocities as high as 20 times the speed of sound, which makes it an extremely useful tool in this age of supersonic flight, missiles, and space exploration.

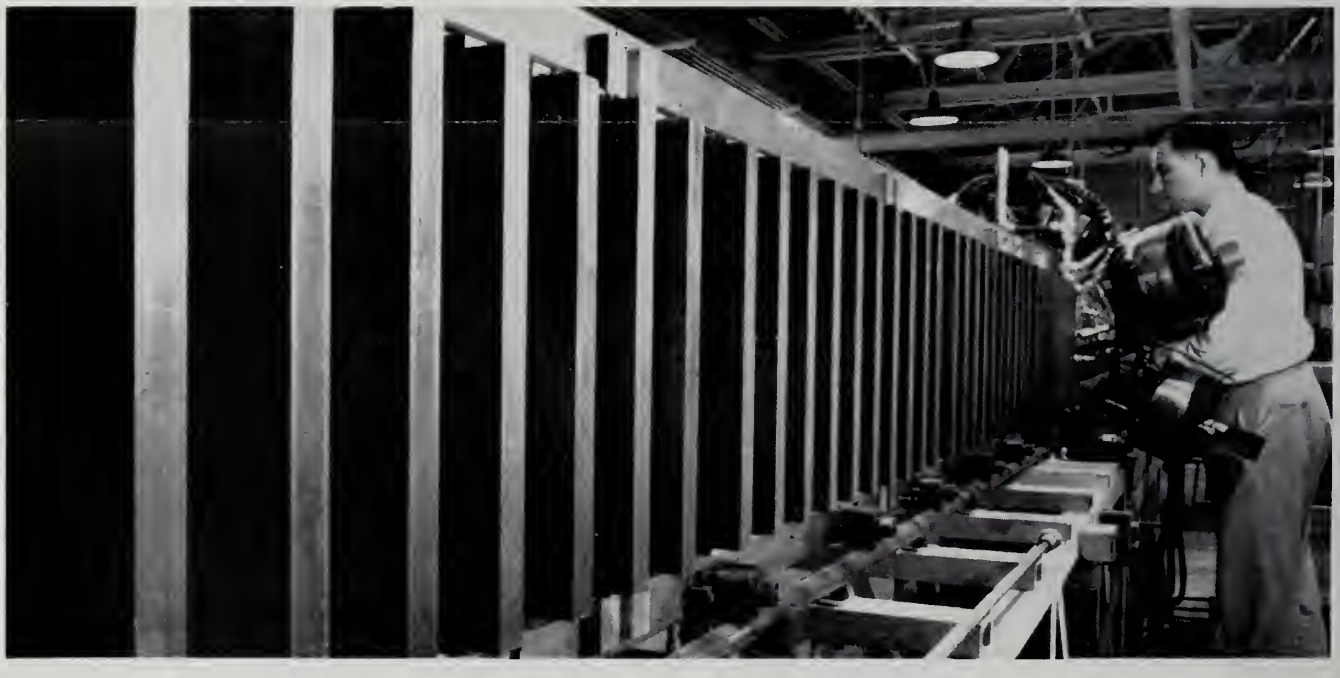
The shock tube was built in 1950. It was a single-diaphragm tube designed to produce shock waves of velocities approaching two and a half times the speed of sound. Such wave travel was produced by raising the pressure of an inert gas in one section of the tube to a pressure sufficient to suddenly break the diaphragm. The high pressure gases would then rush into the other end, compressing the gas in the low pressure section and thus producing a shock wave.

The modified tube is a double-diaphragm design with a combustion driver section, which makes it possible to heat the driver gas and thereby get increased velocities without proportionately increased pressures. So the 52-foot tube now has three sections: a combustion driver, a buffer, and a driven or test section. When the gas in the combustion section is brought up to the desired temperature and pressure, it breaks the first diaphragm and drives the gas in the buffer section into the second diaphragm with great force. This diaphragm then ruptures, releasing the gases into the test section at high velocity. At Mach 20, the wave travels the 30-foot length of the test section in less than .002 second, and raises temperatures up to 11,000° F for times up to about .0001 second.

The shock tube is used for many different kinds of research projects in aeronautical engineering and in undergraduate laboratory experiments in aerodynamics. Some of the current studies include nose-cone atmosphere–re-entry temperature studies, microwave research for Gaseous Electronics, and chemical reaction studies in cooperation with the Department of Chemistry and Chemical Engineering.

The last project is a good example of the usefulness of this high-speed, high-temperature device. Chemical reaction processes do not increase in direct proportion to a temperature increase, so it is usually impossible for a researcher to calculate the chemical reaction which will occur at temperatures which are higher than the melting point of known container materials. He needs to measure directly, but, under ordinary circumstances, can not do so. With the help of the shock tube, he can. It will withstand thousands of degrees because the temperature rises and drops so quickly there is no damage to the inner walls of the tube. And this short transit time interval (2×10^{-3} sec.) is no disadvantage, because it is

The double-diaphragm shock tube is designed to produce Mach 20 shock waves. Professor Harold Barthel is shown putting a new diaphragm into the tube in preparation for an experiment.



still much longer than the shock heating time for any gas, which is approximately 10^{-9} second.

The shock tube is now a valuable asset to the Aeronautical Engineering Department's work at the high-speed, high-altitude end of the spectrum. There is, of course, still much work being done on piloted airplanes, but this now ranges from vertical take-off and landing vehicles to space planes. At the low-speed, low-altitude end of the Department's range of interests are the ground effect machines, wheelless vehicles that move close to the ground or water surface on "cushions of air."

The vehicle performance spectrum illustrated by these examples indicates the breadth of interests of the Aeronautical Engineering Department today, and also shows that "higher and faster" is not the only direction aircraft technology is moving. "Lower and slower" vehicles, also of great importance today, can be studied in the laboratory without too much difficulty; however, vehicles at the high-speed end of the spectrum could not be studied on the ground at all without the use of such machines as the shock tube.

U. OF I. TEAM TO PROBE IONOSPHERE

Next spring a specially fitted Aerobee rocket will be fired from Eglin Field, Florida, which will culminate months of cooperative research by U. of I. engineering faculty. Engineers from the Electrical Engineering Department's Gaseous Electronics and Antenna Laboratories have worked together to provide the rocket's instrumentation, antenna system, and information gathering components. The basic experiment will be an attempt to extend to the actual ionosphere the laboratory "cross-modulation" technique developed in the Gaseous Electronics Laboratory under the direction of Professor L. Goldstein.

Because the ionosphere reflects radio waves at the frequencies used for short wave and commercial radio broadcasting, the development of techniques to control ionospheric disturbances that frequently interfere with such communications has long interested scientists. In this experiment, the rocket will be fired through the lower regions of the ionosphere, which are 45 to 65 miles above the earth. For the cross-modulation experiment, the rocket will carry a transmitter that will send out a high-powered radio signal at the "gyro-frequency" (about 1400 kilocycles), followed by a low-powered "sensing" signal. The temperature of the electrons in the ionosphere near the rocket will be raised by the first signal, which will change the properties of that portion of the ionosphere. The changes will be detected and measured by the sensing signal which follows.

If the experiment is successful, it will be an important step toward someday using ground radio signals or signals from satellites to control disturbances in the ionosphere that now sometimes impair radio communications.

An Aerobee solid fuel rocket of the sort that will be used in the U. of I. ionosphere experiment next spring is shown being lifted into firing position.

This project is sponsored by the Geophysics Research Section of the Air Force Research and Development Command's Cambridge Research Center. The U. of I. research group is headed by Professors L. Goldstein, M. H. Crothers, and G. A. Deschamps.

Professor Crothers, who is in charge of instrumentation for the rocket, reports that tests of the rocket's circuitry are presently under way. Packaging of these electrical components into the Aerobee nose cone will follow the circuit experiments.

Professor Deschamps heads the group conducting research on antennas for the Aerobee. He reports that present experiments indicate that the rocket will carry two long primary antennas. These antennas will be used to transmit the radio signals for the cross-modulation experiment. Made of flat spring steel, they will be designed to slide out of the rocket to their full lengths while in the ionosphere.

The firing of the rocket will give the U. of I. engineers the opportunity to correlate the results of a test in the actual ionosphere with those already obtained in simulated ionosphere conditions in the laboratory. It also shows that rocketry, which is often thought of as having only military applications, can offer aid to researchers concerned with basic understanding of the physical world.

U. OF I. ENGINEER HONORED

A bronze plaque honoring the late Thomas C. Shedd Professor of Structural Engineering at the University of

Illinois, was presented to the University by the Illinois Society of Professional Engineers at a luncheon in the Illini Union Building, at 12:30 p.m. on Saturday, January 7, 1961. The Board of Directors of the Illinois Society of Professional Engineers held its January meeting that day in the Illini Union Building.

Professor Shedd, on the U. of I. Civil Engineering Faculty from 1922 until his retirement in 1958, died July 11, 1959. He was a member of the Illinois Structural Engineers' Examining Committee from 1944 to 1959 and served as chairman for several terms. He was a member of the Illinois Professional Engineers' Examining Committee from 1945 to 1959 and served as chairman from 1945 to 1948. He was president of the Illinois Engineering Council for two terms. He also served as president and director of the National Council of State Boards of Engineering Examiners. In 1959 the Illinois Society presented him with the Illinois Award in recognition of these services.

NEW DOCTORATE FOR NUCLEAR ENGINEERS

Nuclear engineering at the University of Illinois "came of age" at the Board of Trustees meeting December 21. The Trustees approved the establishment of an advanced educational program leading to the Doctor of Philosophy degree in nuclear engineering.

The establishment of the new program came two years after the University's initiation of nuclear engineering training at the master's degree level. During that period 13 degrees have been awarded and physical facilities have come to include the Illinois TRIGA nuclear reactor, three subcritical nuclear assemblies, a heat transfer loop, a radio chemistry laboratory, and a nuclear metallurgy laboratory. The reactor began operation last July.

In announcing the initiation of the new degree, Nuclear Committee chairman R. J. Martin said, "The program is based on the assumption that nuclear engineering is a new field, building on the existing engineering disciplines and the physical sciences, and dealing with the applications of nuclear reactions and radiations to engineering. Nuclear engineering uses knowledge from many areas of engineering and science. For this reason, the new doctoral program, like the existing master's program, will be directed by a committee with members of the graduate faculty from all departments of the College of Engineering."

The new doctoral program is expected to provide stimulus to the College of Engineering's research in nuclear engineering. "In order to utilize fully our capabilities for productive research, we must have graduate students identified with the program during the time period required for the doctorate. Only with this much time can a continuity of training and research experience be achieved," Professor Martin said.

The new program will provide men with advanced training in a field that is growing rapidly in importance in virtually all fields of industry, research, and the nation's defense effort. Nuclear power and propulsion plants are coming into use for both civilian and military applications. Uses for nuclear technology are being found in industry and agriculture both as research tools and as aids to testing and production. As these uses increase, the need for trained nuclear engineers for research, design, and operation threatens to remain far ahead of the limited supply. The establishment of the nuclear engineering educational program at the University of Illinois, planned and developed over a period of years, will help increase that supply.

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 2, No. 2, FEBRUARY 1961

COOL LIGHT BRIGHTER THAN THE SUN

Pure, cool and intense light from a ruby crystal about the same size and shape as a regular cigarette has been transmitted over a distance of 25 miles. This device is called a laser (light amplification by stimulated emission of radiation). Because the unique device can be used in present studies of light modulation at the University of Illinois, one is being constructed by a group under Professor D. F. Holshouser of the Department of Electrical Engineering.

The laser, originally suggested by researchers at Columbia University and first realized at Hughes Laboratories, produces light that differs from ordinary incandescent and fluorescent light. The laser's light is coherent: the emitted particles of light, photons, have waves which are synchronized with each other. This results in much greater intensity. The light emerging from the laser is confined to a very narrow beam, spreading so slightly that the beam can be detected at great distances. It has been estimated that a four inch lens used in conjunction with the laser could be used to beam a detectable light signal to the moon. In addition, the laser's coherent light is cool rather than hot. Unlike hot bodies, the laser's radiation may be confined to a very narrow spectrum of visible light. Although the laser's light is cool, it has been estimated that the sun would have to be a million times hotter than it is at present to match the laser's brightness at a given frequency.

Basically the operation of the laser involves exciting atoms to a higher energy level from which energy is reradiated in a narrow band of frequencies. Although a knowledge of the complex field of modern solid-state physics and familiarity with the quantum mechanics picture of matter and radiation are necessary to fully understand the laser's secrets, the device is simple in its physical structure. For example, a laser built at the Bell Telephone Laboratories consists of a synthetic ruby rod whose flat, highly polished ends are silvered and whose sides are left open to admit the exciting radiation. The ruby rod is held in the center of a spiral photoflash lamp that lights the ruby with an intense flash of ordinary white light. When the power applied to the photoflash lamp reaches a certain value a beam of red light is emitted through the ruby's silvered ends. It is the special nature of this emitted light that currently intrigues researchers.

Because its highly directional beam can be focused to pin-point sharpness, the laser shows great promise in space communication and navigation. Beamed to satellites and other space vehicles, it may become possible for laser signals to carry more information with less power than present radio signals. Current lasers, however, are limited for communications because they emit their light in short bursts rather than in smooth pulses. But this limitation may not be a shortcoming to other applications in the fields of atomic physics, astronomy, and medicine. The short bursts of light may possibly be modulated to carry much more information than is now possible. If modulation is achieved, it will be possible to have many telephone conversations or television signals transmitted simultaneously over a special kind of communication network — a "light" network!

The U. of I. laser will be used primarily to aid current studies of light modulation being sponsored by the Air Force Office of Scientific Research. Professor Holshouser indicates that when the ruby laser is completed it will be possible for his group to conduct further experiments aimed at increasing knowledge of the promising and rapidly expanding field of light.

AN INVITATION TO VISIT US

From electrons to concrete slabs, from farm tractors to space vehicles, the whole range of engineering education and research will be on display at the annual Engineering Open House, March 10-11. High school students and teachers, practicing engineers and scientists, and members of the general public are invited to attend.

Engineering students, with the help of the faculty, will put the entire College of Engineering on display. Members of Tau Beta Pi, engineering honorary fraternity, are organizing and directing the event.

High school students will find Open House a good opportunity to learn about the many fields of engineering.

Engineering students and faculty will be in the laboratories and at the displays to answer questions about courses of study and opportunities in engineering.

Some of the highlights of Open House this year will be displays in metal cutting techniques, plasma dynamics, and rocket propulsion systems, as well as visits to such major facilities as the nuclear reactor, the ILLIAC computer, the cyclotron, and the betatron. The 3,000,000 lb. tension and compression testing machine will, as every year, flex its muscles every hour on the hour.

Every possible effort will be made to answer our visitors' questions, show them a good time, and (hardest of all) help them find parking spots. For further information and guest parking permits, write to:

Engineering Open House Committee
114 Civil Engineering Hall
University of Illinois
Urbana, Illinois

This dynomometer, designed and built ot the University of Illinois, meosures the verticol ond horizontol components of the cutting force octing on the tip of the tool.

CUTTING COSTS FOR CUTTING METALS

Today making chips in this country costs the machining industry 14 billion dollars a year, excluding "small chips" from grinding, honing, and lapping. Part of this high cost is caused by some of the super hard metals being cut, some of which would serve quite well as cutting tool stock with proper heat treatment. Tool wear for such machining is extremely high, which means low tool life and high production costs.

This figure, which is several billions higher than was predicted 2 years ago, suggests the national significance of metal cutting research programs like the one which has been in progress in the University's Mechanical Engineering Department for more than 15 years. Directed by Professors K. J. Trigger and B. T. Chao, this program has been directed toward finding the basic causes of tool wear. The role of temperature and tool-work compatibility has been clearly established.

Tool-chip interface studies have been made for a number of years. These studies have shown that in metal-machining operations there are two principal sources of heat generation: the shear zone and the tool-chip and tool-work interfaces. The shear zone is the region where major plastic deformation takes place, while both interfaces are sliding areas of contact where highly localized heating occurs.

After a tool has been in use, wear develops both at the tool-chip and the tool-work interfaces. The former manifests itself as crater wear and the latter as flank wear. Investigations at the University have indicated that both are fundamentally of the same nature. Wear may be of the ploughing type or of the diffusion type or both. Diffusion wear plays a major role in tool cratering at high cutting speeds. A portion of the hot chip adheres (welds) to the interface of the tool. Continued heat from the machining process maintains this condition until surrounding tool material is weakened. When another incoming chip removes the adhered material, a portion of the tool material is removed as well.

New metal removal processes such plasma-jet cutting and ultra-high speed machining (150,000 to 450,000 fpm) are being studied as possible solutions to such problems. Much work has been and is being done on finding better cutting tool materials and more efficient methods of cooling the cutting tools.

Temperature studies are but one phase of the attack on metal cutting problems. Modern day demands require not only harder and higher strength materials, but also cheaper and more efficient ways of machining them. It is this latter requirement that is the continual goal of the University's Metal Cutting Research Laboratory.

GRADUATE ENROLLMENT IS UP

Graduate enrollment in departments of the College of Engineering has increased nearly 17% in the past year. The totals, including graduate students in physics, are 1153 in the first semester of 1960-1961, as compared with 986 a year earlier.

Quality, rather than quantity, is the primary requirement for the graduate training of engineers, but growth in numbers has some importance in determining quality. First, of course, it indicates that an increasing number of

the nation's more promising young engineers are choosing the University of Illinois for advanced engineering training. In addition, a substantial number of graduate students makes possible the development of a diversified graduate faculty and a broad research program. These in turn assure strong graduate educational curricula. The physical needs for well-equipped laboratories and library collections can be met more readily and economically with substantial numbers of graduate students making use of them.

Specific comparisons of trends in individual departments are shown in the table below.

NEARLY 2 BILLION MILES A DAY

While it is often said that this is the age of the superhighway, it might better be called the age of the street. Americans are traveling *650 billion miles a year* in their automobiles, and 60% of this travel is urban movement. In fact, the movement on superhighways going through or close to cities is 75-80% local traffic! This situation, partly the cause and partly the effect of the buildup of suburbs, suggests the impact of highways on urban life.

To understand this impact and the complex issues of coordinating highway and urban development was the purpose of the American Association of State Highway Officials (AASHO) Urban Planning Seminar at the University of Illinois January 29 through February 1. This was 1 of 4 such seminars which covered the 4 AASHO regions of the United States. The other 3 were held at the University of California, MIT, and the University of North Carolina.

The seminar was attended by chief administrators and top urban people of Region III, the Mississippi Valley states area. It was sponsored by the Division of University Extension, the Department of Civil Engineering, and the Department of City Planning and Landscape

This railrood wheel is undergoing a simulated emergency braking test in the U. of I. Railway Labs at an equivalent train speed of 115 m.p.h. Such tests hove proved that, controry to popular apinian, the caefficient of frictian will increase with an increase in temperoture at a given brake shoe pressure. In tests af sufficient duratian, the heot indicoted by the sparks will frequently weld the brake shae to the wheel when the wheel staps ratating. Such tests date from 1898, when the University instituted its progrom of railway engineering.

GRADUATE COLLEGE ENROLLMENT

Fall Semester 1960-1961

DEPARTMENT	FIRST-YEAR GRADUATE STUDENTS	BEYOND FIRST YEAR	NON-DEGREE CANDIDATES	TOTAL
Aeronautical Engineering	15	15	...	30
Agricultural Engineering	13	...	1	14
Ceramic Engineering	6	9	...	15
Chemical Engineering	18	27	1	46
Civil Engineering	160	95	10	265
Electrical Engineering	146	109	2	257
Mechanical Engineering	88	47	1	136
Metallurgical Engineering	19	23	...	42
Mining Engineering	4	2	...	6
Nuclear Engineering	27	1**	...	28
Theoretical and Applied Mechanics	32	43	...	75
NET TOTALS	528	371	15	914
PHYSICS*	126	110	3	239
TOTAL INCLUDING PHYSICS	654	481	18	1153

* No graduate degree in Engineering Physics.
** Included as M.S. in Civil Engineering also.

Architecture. These groups were represented, respectively, by Mr. Norman W. Johnson, Professor Ellis Danner, and Professor William I. Goodman, the Seminar Coordinator. Professor Danner is the Director of the Illinois Cooperative Highway Research Program and is in charge of highway engineering at the University.

The basic problem facing the seminar attendees was how to route highways in relation to city locations for the greatest possible safety, convenience, and economy. Routing them away from or around cities is not the answer because the proportion of through, cross-country travel is slight compared to town-to-town or suburb-to-business district traffic flows. Routing them through the cities is not a perfect solution either, because slower local traffic flow may congest the throughways and cause dangerous situations for fast-moving through traffic.

Problems like these show the great importance of highway design to the social, psychological, political, and economic aspects of urban life. The far-reaching effects of this seminar, as well as the other 3, are hard to imagine; but at 650 billion travel miles a year, they are significant first steps in the direction city planners and highway engineers are going to move in the future.

THE PLAIN CONCRETE FACTS

Two thousand years ago, Roman engineers using plain concrete to build aqueducts were practicing the *art* of engineering, and they were good artists. But they understood very little of what was actually happening in the concrete or what the material's range of capabilities might be. What they knew was learned by long, costly, trial and error experience. Two thousand years ago there was time for this knowledge to accumulate through generations.

Today engineers are in a bigger hurry to know, and the range of their problems extends far beyond aqueducts. Today the engineer seeks to understand his materials and their capabilities so that he may safely predict their behavior in new and unusual applications.

The key to predicting the behavior of concrete under various environments and loadings is an understanding of the basic structure and properties of the cement gel. This understanding has been developed only in the past 10 years. Proper coordination of the information now available can lead to some anticipation of the progress in the effective utilization of concrete. This is the goal of the Second Conference on Fundamental Research in Plain Concrete, to be held September 5-8, 1961.

The Conference will be held at the University of Illinois conference center at Allerton Park, near Monticello, Illinois. A variety of topics will be discussed, including kinetics of hydration, rheology of concrete, origin and nature of strength, fracture, and aggregate reactions. As this list of topics indicates, it will be a conference for specialists in the concrete field.

The organization of this Conference was stimulated by the success of the first Conference, held in September of 1958. Organizations sponsoring this Conference are the American Concrete Institute, the American Society of Civil Engineers, the American Society for Testing Materials, the Portland Cement Association, the Reinforced Concrete Research Council, and the University of Illinois. Financial support for the Conference is being provided by the National Science Foundation.

Further information concerning the Conference is available from Professor Clyde E. Kesler, Department of Theoretical and Applied Mechanics, University of Illinois, Urbana, Illinois.

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ENGINEERING OUTLOOK
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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 2, No. 3, MARCH 1961

PHYSICAL METALLURGY COLLOQUIA — VISITORS WELCOME

Distinguished metallurgists from the U. S. and abroad are featured in the spring series of physical metallurgy colloquia being held by the Department of Mining and Metallurgical Engineering on the campus in Urbana.

The entire series for the spring semester has not yet been scheduled, but two of the speakers will be Dr. M. J. Marcinkowski, Fundamental Research Laboratory, U. S. Steel Corporation, Monroeville, Pennsylvania, and Professor Paul Gordon, Department of Metallurgical Engineering, Illinois Institute of Technology, Chicago. Dr. Marcinkowski will speak on "Direct Electron Microscopic Observation of Dislocations and of Domain Boundaries in Ordered Alloys," on April 5. On April 19, Professor Gordon will speak on "Mechanism of Recrystallization."

On February 22, the speaker was Dr. L. M. Clarebrough, Division of Tribophysics, University of Melbourne, Victoria, Australia. On March 8, the speaker was Dr. V. Gerold of the Max Planck Institute, Stuttgart, Germany.

Professor Paul A. Beck, who schedules the colloquia, points out that they are held primarily for faculty and graduate students at the University, but he emphasizes that visitors from industry or other institutions are welcome. The colloquia are held at 4:00 p.m., on the dates listed, in Room 218 Ceramics Building on the Urbana campus.

As the topics, speakers, and dates of later colloquia are known, they will be published in *Engineering Outlook*.

LISTENING TO STARS

People have looked at the stars for centuries; now there are people who listen to them. These are the radio astronomers, and their "ears" are radio telescopes. These instruments hear sources of radio emission from "stars," most of which are invisible even to the most powerful optical telescope. These emitted signals or radio waves are picked up by the radio telescope's reflecting surface, bounced up to a collecting antenna that converts the energy into electric current, passed on to a sensitive receiving mechanism and finally recorded graphically by an instrument that traces the finished astronomical data on paper.

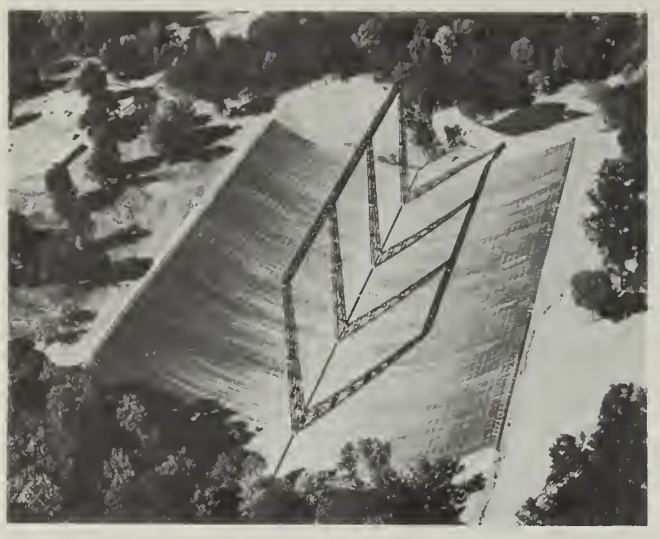
If the radio star's signal were stronger than the noise generated within the receiver of his radio telescope, the radio astronomer would be able to listen to a steady hissing noise that is similar to the hiss made by a home radio set. However, the "noise" is more often impossible to hear, being on the order of one-millionth the amplitude of the radio's hiss.

Because the radio telescope is a valuable tool in helping man to know more about the universe that surrounds him, there has been a steady increase in the number of these instruments constructed within the last few years. One such instrument is being built by the University of Illinois in a reshaped ravine five miles southeast of Danville, Illinois. The instrument is financed primarily by the Office of Naval Research with substantial contributions by the University's Research Board.

An important element of the U. of I. radio telescope, a project of the Departments of Astronomy and Electrical Engineering under the direction of Professors G. C. McVittie and G. W. Swenson, Jr., is its large parabolic reflector. This reflector, a curved "radio mirror" 600 feet long by 400 feet wide cut into the earth, is covered with a welded wire mesh laid on an asphalt and wood fiber blanket. To form the reflector, earth moving machines scooped out approximately 58,000 cubic yards of earth.

Signals from distant radio stars will be reflected from the curved trough up to 265 logarithmic-spiral receiving antennas. These antennas, specially designed for the U. of I. radio telescope by Professor John Dyson of the Electrical Engineering Antenna Research Laboratory, are unique in that they provide a simple method of scanning the antenna beam from north to south. Scanning in the east-west direction will be accomplished by the rotation of the earth; thus about one-third of the sky will be accessible to the instrument. The arrangement of the spiral antennas into an array which can be scanned in declination was designed by Dr. J. T. Lo.

The nondirectional antennas are located 155 feet above the curved earth mirror and are supported by four



Construction is nearly completed on the towers ond reflector of the University of Illinois rodio telescope, 5 miles southeost of Donville. The ravine hos been shaped into o porobolic "rodio mirror" 600 feet long ond 400 feet wide. The outo just obove shodow of top tower ond the mon standing just to the right of centerline between the two middle towers show the size of the reflector.

towers linked together by a catwalk 425 feet long, centered in the reflector. The towers and connecting catwalk are constructed of heavy wooden timbers. These timbers have been treated with a creosote preservative that gives the structure a light brown color. Interlaced with a maze of wooden braces, the towers and catwalk are held together, for the most part, with hundreds of large nonmetallic fasteners. The plastic bolts, wooden nuts, and wooden washers are used to prevent possible antenna pattern distortion.

Used in conjunction with an optical telescope, such as the giant 200-inch Palomar telescope, a radio telescope can be a celestial "finger" pointing to heretofore unrecorded heavenly bodies. Once the radio telescope pinpoints a source of radio noise, the optical telescope is aimed in that direction and photographic plates are exposed for a number of hours. In this way, mapping of the farthest reaches of space can be accomplished — and listening to the stars pays off.

MEETING OF MINDS, HUMAN AND ELECTRONIC

Can computers think? Can they learn? Are they aware of themselves? And how do they compare with man in these respects? There are probably as many different opinions as there are people to think up these questions. They are actually questions which can not be answered at present, not because we do not know enough about the computers, but because we do not know enough about ourselves. The problem is one of logic and semantics. We can not define "thinking," "self-awareness," "intelligence," or "learning" — and it is meaningless to try to compare men and computers if we do not agree on the meanings of these terms. But it is interesting to note that the more fully any of these attributes can be described, the better a computer can be made to simulate them.

The biggest single difference between men and computers is that men do not have to be precise and computers do. Man's lack of precision is responsible for many of his successes and many of his failures, while the computer's extreme precision accounts, for example, for its abilities in rapid computation and its shortcomings in versatility. Man is a jack-of-all-trades and the computer is a narrow specialist.

But by most definitions computers do think and do have intelligence. Most people in the computer field agree on this and do not bother themselves with such questions; they are much more interested in: "How can we make the sort of thinking the computer can do more beneficial to man?" This is the basic question behind all the activities of the University's Digital Computer Laboratory, an interdisciplinary research facility under the U. of I. Graduate College.

The Laboratory and its equipment are available for use by all groups or departments on campus. In addition to this service function, the Laboratory personnel engage actively in computer research, and there is a graduate training program associated with every research program. These programs number six at present: computer design and construction, computer circuits, switching theory, automatic analysis of extensive data, numerical analysis, and studies on efficient methods of using computers.

The Computer Laboratory has two large computers at the present time and will soon have a third. The two pieces of existing equipment are an IBM 650 with magnetic tape units and the ILLIAC, a general purpose computer which was designed and built by University personnel in 1952. The IBM machine provides computing facilities for punched card data and is used both for University administration work and research problems. The ILLIAC is a binary type digital computer, using numbers consisting of a sign and 39 binary places with the fixed point following the sign. In other words, one might say that ILLIAC only knows two digits: zero and one!

ILLIAC has two memories, one providing random access to any of 1,024 words of binary digits, and the other having a capacity of 12,800 words. Input to the machine is normally by standard five-hole paper tape, and output may be obtained by the same type of tape. A data plotter also provides a visual display of results. A library of

machine routines has been prepared which facilitates efficient use of the computer on many scientific problems. With this system many complicated problems can be solved without extensive additional programming. ILLIAC is in use substantially 24 hours a day. Its major users include the various departments of the College of Engineering.

For the last three years the Laboratory personnel have been designing and constructing ILLIAC II, an ultra high-speed computer 100 to 200 times faster than ILLIAC. The comparative speeds for less complex functions are shown by this table:

	ILLIAC	ILLIAC II
Addition	92 microseconds	1.5 to 2.5 microseconds
Multiplication	700 "	5 to 7 "
Division	965 "	15 to 20 "

In other words, ILLIAC II could multiply two 52 digit numbers together and give an answer within five millionths of a second!

ILLIAC II will also have two memories, the capacities being 8,192 words in the main unit and 65,536 words in the auxiliary. Input and output facilities will include punched cards, punched paper tape, and magnetic tape.

The personnel of the Digital Computer Laboratory all hold joint appointments with other departments, either Mathematics, Electrical Engineering, or Physics. Although there is no degree awarded in digital computer work, students in Math, EE, or Physics may write theses with staff members of the Laboratory.

The Computer Laboratory personnel point out that both the man and the machine do the job for which they are best fitted: the computers take over many time-consuming computational tasks, freeing man's mind for the more creative thinking the computer can not do. The Laboratory personnel themselves feel the obligation to do whatever they can to help keep and improve the harmony and efficiency of this man-machine partnership.

PREDICTING THE BOUNCE PER OUNCE

Anyone who has seen railroad rails move up and down when train wheels pass over them can appreciate the problems in designing a free-flight rocket launcher. The design has to be a compromise between the unwanted flexibility inherent in lightweight mobile launchers and the desirable rigidity which accompanies a massive system. Some aspects of this problem have been resolved by a research group under Professor Marvin Stippes of the Department of Theoretical and Applied Mechanics. The project has been sponsored by the Rock Island Arsenal of the Army Ordnance Corps since 1957.

Because of the lightweight characteristics of a mobile launcher, the moving mass of the rocket causes a deflection in the launcher rails, a movement which can have significant effect on the rocket's flight path. Some of the problems have been to learn how much deflection and pitch velocity were being imparted to the missile at the end of guidance, and how much variation there is from launcher to launcher or from missile to missile. These rockets are tactical weapons which require single-

An Honest John rocket being fired from a mobile launcher of a sort being studied by the University of Illinois group.

shot pinpoint accuracy, and achieving it is equivalent to hitting the bull's-eye with a bullet fired from a flexible-barreled rifle not held in a fixed position.

During this study a number of analytical design factors have been computed and passed on to the appropriate agencies. Equations of motion have been worked out, and much information has been accumulated relating pitch velocity to the various geometrical and material parameters of the launcher system. Surprisingly enough, a launcher does not need to be designed to satisfy the static requirements of stability. A launcher system may be completely unstable with the missile placed at the end of the beam, but completely stable under firing conditions. The investigators have established bounds on the size and flexibility of the system to satisfy the requirements of dynamic stability. If one knows how flexible his rifle is and how much it deflects, he can still put a bullet in the target. If he also knows the limits of variation between various rifles and bullets, he can score a high percentage of hits out of a large number of firings. Application of the results of this fundamental research has enabled the sponsoring agency to improve the accuracy and at the same time reduce the weight of important equipment by as much as 30 per cent.

PARTICIPATION IN ROOFING STUDIES

An interesting construction feature of a modern community is the large acreage of flat built-up roofing used on such buildings as shopping centers and schools. These roofs offer economy and ease of construction for large buildings, and they are often the only possible choice from the standpoint of appearance.

But in spite of their advantages, these flat surfaces take a beating from the weather. Solar intensity, rain, frost, ice, cyclical thermal expansion, and moisture penetration from below have resulted in many roof failures. Some of these failures involve thousands of dollars in damage and resulting law suits. In late 1959, the National Roofing Contractors Association turned to the University's Small Homes Council – Building Research Council for help with this urgent problem.

The two-year investigation, under the direction of Professor Donald E. Brotherson of the Department of Architecture, consists of literature surveys, field surveys of roof failures, and laboratory studies. Findings to date suggest that the roofing problem could be one of moisture transport from below, complicated by cyclical heat flow of unusually large magnitude. Professor J. R. Carroll of the Mechanical Engineering Department is serving as an engineering member of the seven-man Advisory Committee for the project.

BEHAVIOR OF MATERIALS SEMINAR

Mr. George J. Verbeck, manager of the Applied Research Section of the Portland Cement Association, is giving a series of lectures this semester for a Theoretical and Applied Mechanics seminar on the Physical Chemistry of the Behavior of Materials. The lectures, to be held in 302f Talbot Laboratory, are scheduled for 2:00 P. M. on approximately every other Monday. The next lecture is scheduled for Monday, March 27th.

Anyone interested in the physical chemistry of cement, concrete, ceramics, polymers, glasses, metals, and wood is welcome to attend. For further information about scheduling or lecture content, contact Professor Clyde E. Kesler, 103 Talbot Laboratory, University of Illinois, Urbana.

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ENGINEERING OUTLOOK
AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 2, No. 4, APRIL 1961

1960 ENGINEERING RESEARCH SUMMARIZED

The 1960 research program of the Engineering Experiment Station, with a total budget of nearly 7½ million dollars, is reported in detail in the *Summary of Engineering Research 1960*. During fiscal 1960, 266 projects were sponsored by 35 private companies, 19 industrial associations, 5 private foundations, and 52 federal and state agencies. During this same period there were approximately 350 investigations under way, including both sponsored and University-supported research.

Of the total budget, approximately $5,613,000 came from various federal government sources, $637,000 from industry, private foundations, associations, and operating agencies of the state of Illinois, and $1,213,000 from the general funds of the University. The role of the Engineering Experiment Station as the coordinating agency is described in the introduction of the booklet.

The 13 engineering departments discussed include Aeronautical, Agricultural, Ceramic, Chemical, and Civil Engineering; the Coordinated Science Laboratory; Electrical, General, Mechanical, Mining and Metallurgical, and Nuclear Engineering; Physics; and Theoretical and Applied Mechanics. The Digital Computer Laboratory and various supplementary research facilities that are not in the College of Engineering are included because they play an important role in many engineering research projects.

Each project is summarized, and a list of publications resulting from the research is included. Researchers and sponsors are identified for each project.

This material is compiled into a 144-page booklet which is free of charge. It is available upon request from the Engineering Publications Office, 114 Civil Engineering Hall, University of Illinois, Urbana, Illinois.

PLATO JOINS THE FACULTY

The responses made by a student tell the teacher how well the student is comprehending and how fast he can go. This "feedback," important to us in everything we do, is doubly important in the student-teacher relationship, where efficiency depends entirely on the understanding of each by the other. The principle of feedback has been incorporated in a teaching machine system recently constructed by the University's Coordinated Science Laboratory.

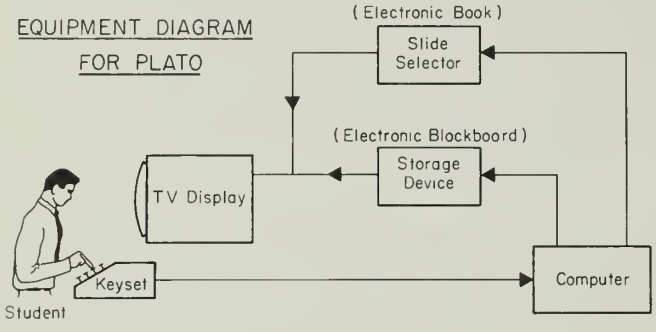
The development of the machine, which is named PLATO (Programmed Logic for Automatic Teaching Operations), is directed by Professors D. L. Bitzer and P. G. Braunfeld. The two main objectives of the project are, first, to design and build equipment enabling student and machine to communicate with each other, and second, to write and evaluate programs that control the teaching operation within the computer. Basically the present equipment, which uses the ILLIAC computer for brainpower, consists of a slide reservoir, a storage tube which will permit material given by the student or by the computer to be displayed with the slides, the screen of a closed-circuit television system, and the student's control panel. It might be said that the device is an electronic blackboard and textbook with a talent for prompting.

PLATO, like its namesake, asks questions and makes men think. Through feedback from the student, it adjusts to individual ability and speed of comprehension; it will allow the exceptional student to progress at high speed, while a less capable one can proceed at a slower rate. Only the facts which would allow the superior student to solve the problem are initially given. A less advanced student, through his control panel, can ask for more information. He can continue to get more facts, or even review early facts, until he solves the problem. The control panel is so designed that the student can use the computer for calculations necessary for solving problems. At the end of the sequence the machine issues a card containing complete information on the student's performance and results.

The feedback between this machine and the student is similar to the feedback between a human teacher and student. The present equipment will teach one student at a time, and has been programmed to give instruction in mathematics and French grammar. Ultimately it will be modified to teach many students at the same time (still giving individual attention to each), and it will be

programmed to teach other subjects. There is no foreseeable difficulty in having it teach a number of students at once because each student relationship requires only a tiny fraction of the computer's "attention."

The subject-matter PLATO could teach varies greatly. Through slides, it can "lecture," give textual instruction, and show any sort of graphic or explanatory material. One eventual goal is to program it to teach students how to program computers. This would be good for two reasons: all engineering students will need training in computer operation in the future and teaching it by computer would not only give the student the necessary theory but also practical experience in computer operation.



PLATO received its first public demonstration in March at the President's Faculty Conference on "improving our educational aims in the 60's." ILLIAC, of course, remained on campus, but the rest of the equipment was 30 miles away, the site of the conference and the demonstration. Educators present agreed that PLATO is significant not only because of its ability to react to the student's individual abilities but also because it offers a method of scientifically studying and ultimately controlling the variables which affect learning speed.

SUMMER TRAINING PROGRAM

To stimulate interest in engineering and science among outstanding high school students, and to let them see for themselves the engineering and science program offered by their state university, the University of Illinois is again conducting a six-weeks' Summer Institute in Science and Engineering. The program, sponsored by the National Science Foundation, will be held on campus from June 12 through July 21. Approximately 40 students who will be Illinois high school seniors in the fall of 1961, ordinarily those who are in the upper 10 per cent of their classes, will be eligible for the program. The deadline for applications is May 1, 1961.

Announcement brochures have been mailed to high schools throughout the state. Application forms may be obtained by writing Professor J. S. Dobrovolny, Director, 117 Transportation Building, University of Illinois, Urbana, Illinois.

ASCE HYDRAULICS CONFERENCE

The rains in the plains of central Illinois are rare in August, but there will be plenty of water on the University of Illinois campus when the Hydraulics Division of the American Society of Civil Engineers holds its Tenth Annual Hydraulics Conference here August 16-18. Co-hosts of the national meeting are the University of Illinois and the Central Illinois Section of ASCE.

Since August may be hot as well as dry, the six half-day technical sessions will be in the air-conditioned auditorium of Gregory Hall. The expected 300 conference participants will be housed in recently constructed dormitories on the campus.

The technical sessions will feature papers by nationally known experts in the fields of ground water hydrology, surface water hydrology, hydraulic structures, sedimentation, hydromechanics, hydrometeorology and flood control, and a tour of the Illinois State Water Survey Meteorology Laboratory at the University Airport.

A field trip on the morning of August 19 will take the group to the National Petro-Chemicals Corporation's modern plant at Tuscola, Illinois. The trip will include inspection of the plant's unique water supply and disposal systems.

While the engineers consider technical matters, their wives and children will have their own field trip, an all-day Lincoln Tour on Friday, August 18, in air-conditioned buses. The tour will go to Springfield and New Salem State Park. The group will visit Lincoln's Home and Tomb and the restored village of New Salem, where Lincoln lived and worked as a young man. During the three-day meeting, young people will conduct their own hydraulic studies at the new Champaign Park swimming pool and Lake of the Woods.

Additional information may be obtained by writing to Professor J. M. Robertson, 125 Talbot Laboratory, University of Illinois, Urbana, Illinois.

THE HIGHEST HURDLE: MATERIALS SELECTION

How can an engineer best contribute to new scientific and engineering achievements? If you ask the leaders in such fields as missiles and nuclear power, their answer is: "Materials problems are the greatest obstacles to progress in our field; we need men who can solve these problems." And so it goes, from building mousetraps to nose cones, transistors to tin cans; finding the material that will economically and functionally satisfy the requirements of the job is the highest hurdle on the road to accomplishment.

The most versatile of all materials are metals, and the role of the metallurgist is critical and challenging. It is his job to design and produce the right alloy for each of

the multitude of different applications in which metals are asked to serve.

In order to handle these assignments, the metallurgist must understand the structure of atoms, the fundamental building blocks of all materials. He must know how they are assembled into crystalline structures, and how defects in these structures affect the materials they make up. He must further study how the way these crystals are joined together affects the properties of the metal. Then he must learn how variables such as composition, melting and casting procedures, heat treatment, and deformation affect the properties of the finished metals.

The metallurgist must understand the ways in which metals fail — wear, corrosion, creep, fatigue, fracture — and from this knowledge, design metals which are able to resist service failures.

There is a pressing need for metallurgists in all phases of industry today. The number of metallurgists graduated from just one large Russian university equals the total number being graduated by all schools in this country.

The metallurgy curriculum at the University of Illinois is built around a core of physics, chemistry, mathematics, and metallurgical engineering courses. Ample freedom in the selection of additional courses allows the student to follow his personal interests, whether they be along lines of scientific research or preparation for a career in production operations in industry.

The courses are taught by a large staff whose interests cover the broad range of topics in the field of metallurgy. The department has a strong graduate program and extensive research activities, some of which are sponsored by industry. Many undergraduates find part-time employment by helping with this research.

Those interested in further information about the field of metallurgy or the educational programs in that area of study at the University of Illinois are urged to write to Professor T. A. Read, Head, Department of Mining and Metallurgical Engineering, 311 Ceramics Building, University of Illinois, Urbana, Illinois.

DEFLECTIONS IN ELASTIC SHELLS

Engineering Experiment Station Bulletin 458, *Theory of Non-Homogeneous Anisotropic Elastic Shells Subjected to Arbitrary Temperature Distribution,* by R. E. Miller, is now available for distribution. This is a general theory for shells that are homogeneous through the thickness but otherwise unrestricted in homogeneity and isotropy. The theory is specialized for arbitrary cylinders, circular cones, spheres, and axially symmetrical orthotropic shells of revolution. The price of the 36-page bulletin is one dollar per copy.

ENGINEERING AND AGRICULTURE

Although agriculture is both one of the world's oldest and largest industries, most of the technology to increase the agricultural worker's output has been developed since the turn of the century. In 1900, each agricultural worker produced food and fiber for only seven people. By 1940, the food and fiber output of each worker was sufficient for 11 people. Continued mechanization of farming enables today's agricultural worker to produce for 24 people. Very few industries can boast of doubling the output per worker in 20 years.

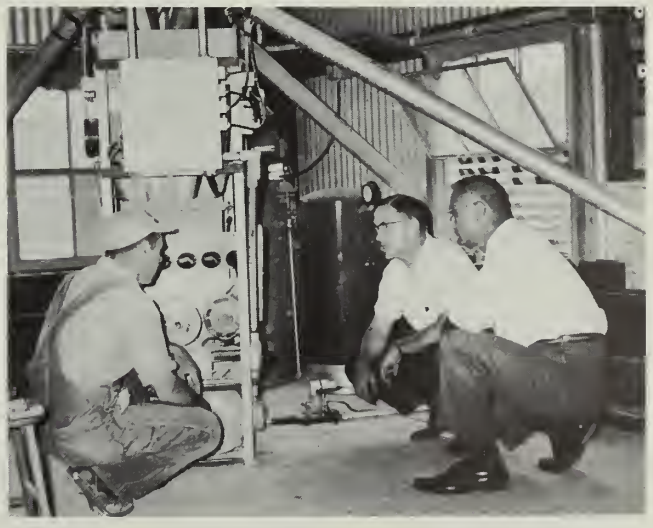
The application of engineering has been responsible for much of the rapid increase in agricultural production but many challenging problems remain unsolved. A large majority of agricultural problems have engineering implications and can best be solved by agricultural engineers since they are trained in engineering principles and also to understand agriculture.

A recent project to decrease the labor involved in feeding poultry was conducted by agricultural engineers at the University of Illinois. The objective of this project was to develop an automatic distribution system in which feed could be piped to the poultry feeders in much the same way water is piped to the waterers.

After considerable research in the laboratory to establish design characteristics, an automatic system for conveying feed through a one-inch diameter pipe was installed on a turkey and poultry farm in Peoria County, Illinois. Each year approximately 14,000 turkeys and 30,000 roasting chickens are raised on the farm.

The feeding system consists of bulk storage bins, an

Automatic grinding, conveying, and feed-line switching may someday distribute feed like water on many farms. This photograph shows the control panel and some of the equipment which make up the completely automatic feed handling system for 14,000 turkeys on the Warren Frye turkey and poultry farm in Peoria County. Frye, left, discusses the system with local agricultural engineers.



automatic hammer mill for mixing and grinding, and a medium-pressure pneumatic conveyor. The system conveys feed at a rate of 1,200 pounds per hour up to a distance of 390 feet through one-inch rigid electrical conduit with 32 cubic feet of air per minute operating under 7½ pounds of pressure per square inch. The grinder and conveyor each require approximately two kilowatts of electric power. The system has been in continuous service since it was installed in June, 1959, and has processed as much as six tons of poultry ration in a single day.

Automatic distribution of feed to several locations with pneumatic equipment is only possible through the development of controls and equipment which can work together to form a satisfactory system. Once such a system is developed, it is capable of unsupervised 24-hour-a-day operation.

This pneumatic equipment is but one example of many recent developments in farm engineering. It takes only a little thought to imagine what engineering may be doing for agriculture in the near future. Meeting the needs of modern agriculture offers the engineer a great challenge and unlimited opportunities for creativeness.

TEACHING COMPUTER USE TO UNDERGRADUATES

Two common themes in many *Outlook* stories have been speed and complexity, problems that contribute to the difficulties inherent in the engineer's work. These factors sometimes complicate projects to such an extent that solutions would be impossible without the engineer's invaluable assistant, the computer. The computer offers help in two ways: it serves as a "super slide rule," permitting mathematical computations in far less time than otherwise possible; and it serves as a decision maker in operating systems on comparisons of stored and entering data. These two basic functions make it an essential engineering tool. For this reason the College of Engineering is developing plans to teach computer use to all undergraduate students.

Such a teaching program will eventually include about 1,000 students a year, or 500 per semester. Computer facilities on the campus (see *Outlook*, March, 1961) are extensive enough to handle such a load. In addition to the ILLIAC and an IBM 650 now in use, ILLIAC II, an ultra high-speed general purpose computer, is presently being designed and built. ILLIAC II, when completed, is expected to free ILLIAC for this instruction program.

A pilot course for approximately 75 students is planned for the fall of 1961. This is expected to grow gradually over a two-year period until the course is required for all engineering students by the fall of 1963. The three-hour course is planned to consist of five basic topics: elementary machine organization; problem formulation, programming, and problem oriented languages; numerical analysis; machine languages, properties, and programming; and applications of computers. Later in his college career the student will be able to use the computer facilities for solving complex problems in his advanced courses.

A safe (but perhaps uncomfortable) assumption is that tomorrow's world will be more high-speed and complex than today's; if so, computers will assume an even more significant role in man's affairs. This new educational program in the College of Engineering will help prepare the U. of I. engineering graduate to face the complexities of modern engineering practice by giving him an introduction to that indispensable tool, the computer.

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ENGINEERING OUTLOOK
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RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 2, No. 5, MAY 1961

THE SCIENCE OF MODERN MINING

"You load sixteen tons and what do you get?" The answer to the question in this old ballad is that in today's modern coal mine you'd get fired if that was your idea of a day's work. One of the reasons would be that instead of a #2 hand shovel costing $1.50, you would be using a $150,000 continuous mining machine, capable of mining 16 tons in a matter of seconds. Instead of a mule to haul the coal to the surface, you would be depending on various types of belt conveyors. And the mining engineering department of the company would probably have made a complete analysis of the operations involved in getting the coal from underground to the river barges used to transport it to the nearby electric utility plants. Things have changed since the "sixteen ton" days.

The contrast between the #2 shovel and the continuous miner is as great as the comparison between the first courses taught in mining engineering at the University of Illinois in 1870 (the Mining Engineering Department was one of the original four departments established as the College of Engineering) and the present curriculum. In addition to the usual engineering courses in mathematics, physics, and theoretical and applied mechanics, mining engineering students prepare for work in industry by taking additional courses in statistics, fluids, structural design, geology, and electrical engineering. Within their own department, students are taught fundamental concepts which will aid them in designing and analyzing materials movement (both solid and fluid), mineral preparation, and mineral extraction systems.

Although the day is not yet here when a mining engineer can look in a book of tables and determine a safe roof span in a particular type of rock — a span which will permit maximum extraction of the mineral with minimum danger to the men doing the work — much progress is being made through work in rock mechanics. Photoelastic models have for many years played an important part in the analysis of rock stresses, but recent work in the U. of I. Mining Engineering Department indicates that a new analytical method of computing stresses in a sedimentary bed may be forthcoming. Such a method would use a model concept in which the sedimentary bed woud be treated as a plate acting on elastic supports.

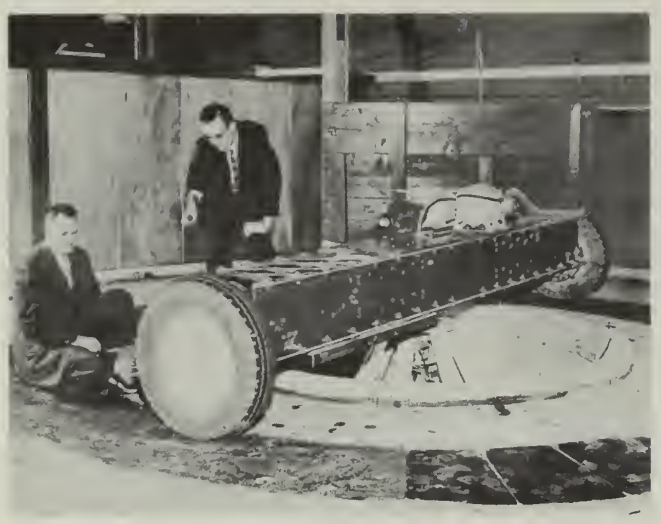
Because of the increasing complexity of the mining industry, the demand for engineers is even greater now than it has been in the past. The industry is concerned about the shortage of mining engineers and is trying to help by supporting several scholarships with stipends of $500 per year. Information on these scholarships may be obtained by writing to the Department of Mining and Metallurgical Engineering, 311 Ceramics Building, University of Illinois, Urbana.

Mineral conservation and safety are demanding that the mining engineer be alert for new developments in science and mathematics in order to be able to continue to produce our ever-dwindling supply of minerals at a profit. If the mining engineer does not keep abreast of developments in rock mechanics, operations research, and computers, he too may be looking for a job in a less exacting field of endeavor than mining is today.

BULLETIN 459

Engineering Experiment Station Bulletin 459, *On the Solution of Ill-Conditioned, Simultaneous, Linear, Algebraic Equations by Machine Computation,* by B. T. Chao, H. L. Li, and E. J. Scott, of the Department of Mechanical Engineering, is now available for distribution. This bulletin describes an iterative procedure, suitable for machine computation, for solving ill-conditioned, algebraic, linear, simultaneous equations. It is based on an appropriate modification of the coefficient matrix for improving the condition of the system. Convergence criterion is established and means of computing the upper bound of error is given. It concludes with numerical examples which clearly demonstrate the usefulness of the method.

The 16-page bulletin is available for one dollar per copy from Engineering Publications, 114 Civil Engineering Hall, University of Illinois, Urbana.



W. E. Chastain, Sr. (left), research engineer for the Illinois State Division of Highways, inspects a highway test track just put into use at the University of Illinois. In a week it can give road materials the beating of a year in service. Showing the equipment is his son, W. E. Chastain, Jr., a graduate assistant at the University. As described in the April 1960 *Outlook*, the first project for the new track is to set standards for use of lime-pozzolan as a base material in secondary roads and city streets. Pozzolan or fly ash, now a waste material, promises reduced construction costs. George W. Hallon, Professor of Civil Engineering, directs test track research projects. Both Chastain and his son are U. of I. engineering alumni.

OUTSTANDING STUDENTS RECOGNIZED

For outstanding scholarship in the University of Illinois College of Engineering, 157 students have been cited on the Dean's List and notice of their superior academic performance was sent to their parents by Dean William L. Everitt. At the end of the last semester each honor student had a scholastic average of 4.5 or better for his entire university work — based on "A" equalling 5, "B," 4, and so on.

Students on the Dean's List are eligible for the College of Engineering Honors Program, under which they have special flexibility in the selection of courses, may select special class sections which give opportunity for extra work, and as juniors and seniors may have special privileges usually associated with graduate student status. Maintenance of a high grade average is necessary to remain in the Honors Program. Honor students receive degrees inscribed "with high honors" or "with highest honors."

GENERAL RATHER THAN SPECIFIC

A student has an ambition to work in a field related to engineering. He needs a fundamental engineering background, but he does not need to delve deeply into a particular engineering curriculum at the expense of time needed for study in the related field. What does he do? At the University of Illinois he enrolls in General Engineering, where he can work toward a bachelor's degree while taking a major in the related field that interests him.

Many students who enroll in General Engineering select for their secondary field of concentration such areas as engineering sales, administration, publications, geology, or meteorology. Other fields, such as law, finance, education, industrial psychology, social sciences, or humanities, may be selected with the approval of the departments concerned. Fundamental training in engineering is the same as students take in other more specialized fields of engineering. General Engineering students take the same engineering graphics, mathematics, chemistry, and physics as other engineering students. They take the basic courses in engineering mechanics, such as statics, dynamics, strength of materials, as well as some work in thermodynamics and heat power. In the field of electricity, they take a series of basic courses in circuits, machines, and electronic devices.

At the beginning of his junior year the student takes a sequence of design courses specifically planned to satisfy his needs in the broad area of project design. During these last four semesters he is allowed to take one or two courses every semester in his related field of interest. The design sequence provides the student the opportunity to apply the knowledge of science he has gained from his first two years' work to the analysis of typical engineering problems. It will give him the ability, up to a fairly high level of complexity, to work in many phases of engineering that are often reserved for various types of specialists: the analysis and design of structures, power requirements, equipment selection or construction, equipment location, as well as the writing of proposals, cost analyses, and reports.

When he graduates, the engineer-geologist, engineer-industrial psychologist, engineering publications specialist, or whatever he may be, depending on what he selected for his major, is in a most desirable position. He is well rounded, having received an excellent background both in engineering and in his related field. He could conceivably work in engineering or in his secondary field, and he could teach in either field after additional study. Many graduates go on for a master's degree in Business Administration, which makes them most attractive to industry for executive positions.

Since 1958, enrollment in General Engineering at the University of Illinois has risen from 242 to 348, an increase of more than 30%. These increasing enrollments, in addition to the successes of General Engineering graduates in many fields, attest to the fact that there is a place on the American scene for engineers who are interested in the "general" rather than the "specific."

EMPLOYMENT FOR FEBRUARY GRADUATES

Midyear engineering graduates have reported that they selected jobs on the basis of these reasons and in this order: (1) type of work; (2) location; (3) opportunity for advancement; (4) salary; and (5) worked summers for the company selected. Although salary was not the most important consideration in job selection, the actual starting salaries were higher than in the past. The average for the 195 graduates who took jobs immediately was $550 per month, as compared to the average of $529 a year earlier.

OF MEN AND MEASUREMENTS

A University of Illinois track coach wants his stop watch repaired.

A flight instructor at the U. of I. Institute of Aviation wants a broken altimeter fixed.

An electrical engineer wants an instrument precisely calibrated so that he can use it in a delicate ultrasonic beam experiment.

At first glance one may see little connection between the needs of the track coach, the flight instructor, and the engineer. There is, however, a connection. The connecting link is the service of the Engineering Experiment Station's Measurement Program. Repairing stop watches, fixing broken instruments, and calibrating measuring devices are only samples of the many types of individual projects that have been handled by the Measurement Program since it began operations in 1948.

Directed by Professor H. N. Hayward of the Department of Electrical Engineering, the Measurement Program provides the entire University with a trained and experienced staff of technicians equipped to handle a wide variety of measurement problems.

This staff-built A-C Calibration Checking Unit is an example of the type standards tool used by Measurement Program technicians to speed up the routine checking of many of the instruments used on the U. of I. campus. This unit is used to check instruments ranging from 0.5 to 100 amperes and voltages ranging from 1.0 to 750 volts.

Not all of the activities of the Program are routine. Recently a U. of I. zoologist wanted an accurate instrument for determining the forces involved in the taking-off and landing of birds! There were no existing instruments for making the desired measurements, so the Measurement Program staff had to start from scratch in designing and constructing an appropriate device.

After a few preliminary attempts, the group produced a finished instrument that met all of the zoologist's requirements. It has a plywood landing platform connected to a series of metal bellows containing hydraulic fluid. Any force, such as that exerted when a bird

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ORDER FORM — send with remittance to Engineering Publications, 114 Civil Engineering Hall, University of Illinois, Urbana, Illinois

☐ Bull. 457, *The Functions and Design of Motor Vehicle License Plates,* J. E. Baerwald, D. F. Karmeier, and C. G. Herrington. *One dollar and twenty-five cents.*

☐ Bull. 458, *Theory of Non-Homogeneous Anisotropic Elastic Shells Subjected to Arbitrary Temperature Distribution,* R. E. Miller. *One dollar.*

☐ Bull. 459, *On the Solution of Ill-Conditioned, Simultaneous, Linear, Algebraic Equations by Machine Computation,* B. T. Chao, H. L. Li, and E. J. Scott. *One dollar.*

☐ *A Summary of Engineering Research: 1960. No charge.*

☐ *Graduate Program in Nuclear Engineering.* Brochure. *Free of charge.*

takes off or lands, compresses these bellows. The expansion and contraction of the bellows activates three ink-filled needles which draw zig-zag tracings on moving graph paper, measuring the three directional components of the force. The bird's take-off or landing force is then determined by evaluating the displacement of each of the pens.

Although such special problems of design and construction offer a change of pace to the Measurement Program technicians, much of their time is devoted to the regular maintenance and repair of conventional measuring instruments such as voltmeters, wattmeters, ammeters and other A-C and D-C indicating instruments. The group performs preventive maintenance on thousands of these sensitive instruments and on all of the microscopes and analytical balances used by the University.

As a result of 13 years of accumulated experience with the adjustment and calibration of delicate measurement instruments, the Measurement Program has taken on many aspects of a standards laboratory. Through the use of their specialized test equipment, much of which was built by staff members themselves, extreme care is maintained in bringing various types of instruments up to their required standards of accuracy.

The sensitivity of measuring instruments and the skill necessary to use them properly have helped to make the Measurement Program particularly valuable to the large and varied research program of the College of Engineering. Because of the complexities of modern day engineering, precise measurement has become a science in itself. Increased attention is being paid today to the exactness of fundamental measuring standards. For example, formerly a bar of metal, marked to an exact length, was accepted as the world's standard for length measurements and a good chronometer was considered adequate for time measurements. But recently adopted standards define a meter, for example, as 1,650,763.73 wavelengths of the orange-red line of krypton-86. A second is now defined as 1/31,556,925.9747 of the earth's rotation around the sun in the year 1900. These examples illustrate how engineering and scientific research have become so sophisticated that researchers require professional assistance in fixing times and measurements — as well as in fixing stop watches and broken instruments.

ENGINEERING AND ATHLETICS

Some people feel that engineering students are kept so busy with their school work they have no time for extracurricular activities. While they are certainly kept busy at the University of Illinois, here are some recently gathered statistics which show that the College of Engineering is well represented in varsity athletics. Only sophomores, juniors, and seniors are included in these figures.

Varsity Sport	*Engineering College Students*	*Students from All Other Colleges*	*Per cent of Squad in Engineering*
Baseball	6	29	17%
Basketball	3	15	17%
Cross-Country	2	8	20%
Fencing	3	10	23%
Golf	0	12	0%
Gymnastics	0	8	0%
Swimming	1	15	6%
Tennis	4	5	44%
Track	2	26	7%
Wrestling	2	9	18%
Football	8	61	12%
Totals	31	198	16%

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 2, No. 6, JUNE 1961

ASCE TENTH ANNUAL HYDRAULICS CONFERENCE

The highlights of the Tenth Annual Hydraulics Conference, sponsored by the Hydraulics Division of the American Society of Civil Engineers and to be held August 16-18 at the University of Illinois, were announced in the April issue of *Engineering Outlook*. More complete details of the technical program and other activities may be found in the May issue of the *Hydraulics Division Newsletter* and the June issue of *Civil Engineering*.

William H. Wisely, Executive Secretary of the American Society of Civil Engineers, will speak on "Society Affairs" at the August 16 conference luncheon. Mr. Wisely is a native of Illinois and a civil engineering graduate of the University of Illinois.

Floyd E. Dominy, Commissioner, Bureau of Reclamation, U. S. Department of the Interior, will speak on "A Challenge to the Hydraulics Engineer" at the August 17 conference banquet to be held in the Illini Union Ball Room.

For further information write to Professor J. M. Robertson, 125 Talbot Laboratory, University of Illinois, Urbana, Illinois.

MAKING THE INSIDE AS BIG AS THE OUTSIDE

A new building frame, made possible by research in the U. of I. Department of Agricultural Engineering, may revolutionize the construction of farm buildings. It has already been so successful that it has been used in many other kinds of buildings where unrestricted space was important. Builders have always been faced with the problem of keeping building interiors as free as possible from superstructure, columns, and supporting ties. Uninterrupted space is particularly desirable for farm buildings, which are often used to house machinery that is bulky and not particularly maneuverable.

The frame is made of lumber. It consists of two studs and two rafters made rigid by plywood gussets glued and nailed on each side of each angle. By doing away with the need for such interior obstructions as ties and posts, the rigid frame provides more usable space at less cost than do the conventional methods of construction. Frames can be made at home or by local lumber yards or builders, and they can be erected quickly and easily.

The idea of the rigid frame was first tried on a small building in 1957. In designing the framing for this building, accepted procedures of structural analysis were used to determine stresses in members. No established procedure could be found, however, for designing the nailed and glued plywood gussets which were subjected primarily to a bending load. Research was therefore undertaken to develop such a procedure. Load tests were made on a series of 88 full-scale joints formed with nailed and glued plywood gussets. Results of this research were used in designing complete building frames.

Joints were made out of construction grade Douglas fir, C-C exterior sheathing grade Douglas fir plywood, and type II casein glue. Nails were used to apply pressure while the glue set. Five sizes of framing lumber were included in the tests: 2 x 4, 2 x 6, 2 x 8, 2 x 10, and 2 x 12. Two thicknesses of plywood were tried for the gussets — ⅜-inch and ⅝-inch. Other variables were the size of gusset and the orientation of grain of the face plies of the gusset.

To design a series of rigid frames, the following loads were assumed:

1. A combined snow load and dead load of 25 pounds per square foot of horizontal projection of the roof surface.
2. A wind velocity pressure of 20 pounds per square foot at a height of 30 feet. This is equivalent to a wind velocity of 88 miles an hour at this height. A correction was then applied for the actual height of the building. The frames were designed for a load resulting from the wind blowing toward the open side of a building closed on the other three sides.

The following allowable working stresses were also assumed:

Erection of this type of structure is simple and can be done rapidly with relatively inexperienced builders. The workmen are shown erecting 2 x 8-inch frames for a 30-foot span building.

1. A stress in extreme fibre in bending of 2,000 pounds per square inch.
2. A stress in compression parallel to the grain of the lumber of 1,600 pounds per square inch.
3. A stress in shear parallel to the glue line of the plywood of 90 pounds per square inch.

Details of the joint tests are given in Agricultural Experiment Station Bulletin 654, "Design of Nailed and Glued Plywood Gussets for Lumber Rigid Frames" by J. O. Curtis. Complete details on frame spacing and fabrication are given in Agricultural Experiment Station Circular 812, "Lumber Rigid Frames for Farm Buildings" by J. O. Curtis and E. L. Hansen. This booklet includes design data for all standard stock sizes of framing lumber from 2 x 4 to 2 x 12, giving the maximum stud spacing for each for spans of 12 to 40 feet, as well as stud heights from 6 to 12 feet. It gives details of gusset dimensions for different sizes of framing, frame assembly methods, foundation plans, and roof constructions. It is available free of charge from the Department of Agricultural Engineering, University of Illinois, Urbana, Illinois.

ASTME EDUCATION AWARD

Professor Lawrence E. Doyle of the Department of Mechanical and Industrial Engineering, University of Illinois, has been named the recipient of the Education Award of the American Society of Tool and Manufacturing Engineers. The Award was presented at the National Honor Awards Dinner on May 20, 1961, in New York City at the Annual Meeting of the Society, which was attended by delegates from 167 chapters in the United States, Canada, Mexico, Australia, and the Philippines. The Award honors men "for developing dynamic curricula, fostering sound training methods, or inspiring students to enter the profession of tool engineering."

THREE CIVIL ENGINEERS HONORED

Three members of the University of Illinois Department of Civil Engineering have been selected as the 1961 winners of the A. Epstein Memorial Award for Faculty Achievement. The recipients are Dr. Benjamin B. Ewing, Associate Professor of Sanitary Engineering; Dr. Mete A. Sozen, Associate Professor of Civil Engineering; and Dr. Houssam M. Karara, Assistant Professor of Civil Engineering.

Funds for the Award are contributed by the firm of A. Epstein and Sons, Inc., Chicago, and final selections of recipients are made on the basis of achievement, scholarship, professional standing, contribution to the work of the Civil Engineering Department, and distinction in public service.

A CURRENT PUBLICATIONS CATALOG

A cumulative index titled *Publications 1904-1960* has just been published as a new edition of the catalog of publications of the Engineering Experiment Station. It lists available publications by both author and subject headings, gives prices of publications and reproductions, and a list of publications by departments. It also describes the proper procedures for ordering Experiment Station publications or microfilm and photoprint reproductions of the publications.

The 43-page catalog is available free of charge from Engineering Publications, 114 Civil Engineering Hall, University of Illinois, Urbana.

Professor Jomes Leach of the U. of I. Mechanical Engineering Department is shown teaching a class in faundry practice at the Indian Institute of Technology (I.I.T.) at Kharagpur, India. The University of Illinois has ployed an impartant role in the develapment of the Institute since 1954 (October, 1960, *Outlaak*). Ten ather engineering prafessars have served an the I.I.T. faculty, and a number of the Institute's regular staff members have came ta Illinais far advanced training. Prafessar Leach, wha has just returned fram India, said he has a deep respect far the students and staff at the Institute, as well as for the Internatianal Caaperatian Administratian, which has made the U.I.–I.I.T. program possible.

AERONAUTICAL AND ASTRONAUTICAL ENGINEERING

Teaching and research in the space age, long a part of the work of the Department of Aeronautical Engineering at the University of Illinois, has been officially recognized by a departmental name change approved by the University of Illinois Board of Trustees. The new name is the Department of Aeronautical and Astronautical Engineering.

According to Professor Henry S. Stillwell, Head of the Department, the new name is more descriptive of the work being done in the Department. This work has for years included instruction and research in the areas of missile and space vehicle engineering. Professor Stillwell points out that while the name change does not mean a new direction of interest for the Department, it does indicate the broadening of interests in this department in the last few years.

Some of the projects related to astronautical engineering worked on during the last year include studies in the aerodynamics of vehicles re-entering the atmosphere, missile aerodynamics, and investigations of high-temperature flight structures.

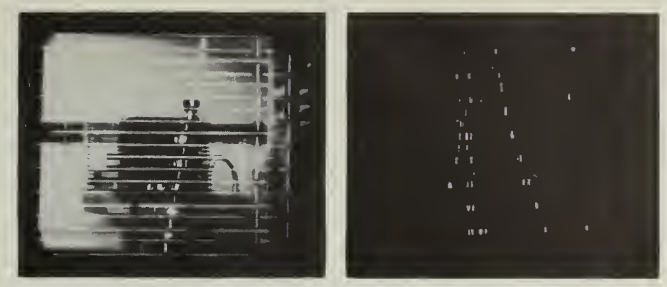
The Department's programs of instruction and research on piloted aircraft are now stronger than ever, with efforts being applied to a wide range of aircraft varying from vertical take-off and landing airplanes to high-altitude hypersonic-speed craft.

Aeronautical engineering has been broadening in scope over the last fifteen years and is expected to change even faster in the future. In its programs in education and research, the U. of I. Aeronautical and Astronautical Engineering Department plans to be as progressive as its new name suggests.

SPARK CHAMBER

The spark chamber is the newest in a long series of devices developed by nuclear physicists for the detection of high energy particles.

In this device flat metal plates are stacked parallel to each other and about ¼ inch apart. They are insulated from each other and alternate ones are electrically connected together. When a particle passes through the stack of plates it ionizes the gas between them; that is, it electrifies the gas along its path. One set of plates is then suddenly raised to a very high voltage — about 15,000 volts within half a millionth of a second. A spark occurs between the plates at the points where the gas was ionized. Sparks therefore trace out the path of the particle. The sparks are very bright and easily photographed, providing a permanent record of the nuclear interaction being studied.



The picture on the left shows the stack of parallel plates in the spark chamber with a spark path caused by a single cosmic-ray particle. The complex apparatus apparently inside the chamber is a reflection of the camera in the front glass window of the chamber. The picture on the right shows the sparks along the paths of several particles in a cosmic-ray shower.

Since the spark chamber is only sensitive for about one millionth of a second after the passage of the particle whose track is to be photographed, some other device must be employed to detect the particle and switch on the high voltage immediately after the particle has entered the chamber. This detecting device is usually a system of scintillation counters which can be arranged so that the spark chamber "looks at" only one specially selected event out of several hundred thousand which take place in it each second. In this respect it is superior to the older cloud and bubble chambers which are sensitive to all particles which have passed through them for a relatively long time before the photograph.

A group of physicists at the University of Illinois is developing these chambers for use at the Betatron Laboratory on the Illinois campus in conjunction with large accelerators at Brookhaven and Argonne National Laboratories.

THE UNDERGROUND ENGINEERS

Some people say a petroleum engineer is a chemical engineer who has gone underground. The petroleum engineer deals with all the processes and exchanges the chemical engineer deals with above ground — fluid flow, fluid displacements, phase changes, mass transfers, chemical reactions, and so on — but the petroleum engineer is interested in these processes as they occur within the rock mantle of the earth.

These processes are influenced beneath the surface by natural forces that differ from the above-ground limits of interest. Since these processes take place within a complex natural environment, almost invariably many of them are occurring simultaneously. In addition, the petroleum engineer's interests usually cover a reservoir, which may have a considerable volume, or perhaps even the interactions of two or more reservoirs.

The goal of petroleum engineering is to get possession of the liquid and gaseous hydrocarbons in the earth. This involves engineering problems related to drilling, lifting

to the surface, and transporting to the refineries. Therefore the practice of petroleum engineering depends largely upon an understanding of the flow of fluids through porous media such as sandstone and limestone.

The undergraduate and graduate programs in petroleum engineering at the University of Illinois emphasize the basic principles of hydrocarbon recovery methods. In addition to a background of physics, mathematics, theoretical and applied mechanics, physical chemistry, thermodynamics, and organic chemistry, students receive training in laboratory and analytic approaches to petroleum engineering problems.

The interests of the metallurgical engineers and the mining engineers were described in the April, 1961 and May, 1961 issues of *Outlook*. These articles gave some information on the make-up of the Department of Mining and Metallurgical Engineering (as it was then named), which has for some years offered Petroleum Engineering as an option in Mining Engineering. The increasing importance of this option is reflected by the Department's new name, now the Department of Mining, Metallurgy, and Petroleum Engineering.

RESEARCH REPORTS AND THESES

The annual publication, *Engineering Departmental Reports and Theses,* is now available as Experiment Station Circular No. 70. It contains abstracts of research reports published by departments of the University of Illinois College of Engineering during fiscal 1959-1960. In many cases the reports themselves are available only as departmental publications for limited distribution.

Doctoral dissertations and master's theses written during the last fiscal year are also listed by department. The 48-page circular includes both an author and a subject index. It is available free of charge from Engineering Publications, 114 Civil Engineering Hall, University of Illinois, Urbana, Illinois.

Recent Publications of the Engineering Experiment Station

A Summary of Engineering Research 1960, 144 pp., free of charge.

Bulletin 457, *The Functions and Design of Motor Vehicle License Plates,* by John Baerwald, Delbert Karmeier, and Gordon Herrington, 61 pp., $1.25 per copy.

Bulletin 458, *Theory of Non-Homogeneous Anisotropic Elastic Shells Subjected to Arbitrary Temperature Distribution,* 36 pp., $1.00 per copy.

Bulletin 459, *On the Solution of Ill-Conditioned, Simultaneous, Linear, Algebraic Equations by Machine Computation,* by B. T. Chao, H. L. Li, and E. J. Scott, 16 pp., $1.00 per copy.

Circular 67, *Manual of Current Practice for Design, Construction, and Maintenance of Soil-Aggregate Roads,* by E. Y. Haung, 145 pp., $1.00 per copy.

Circular 68, *A Comparison of the Performance of Various Room Heating Units Used in the I=B=R Research Home,* by W. S. Harris and L. N. Montgomery, 27 pp., $.50 per copy.

Circular 69, *Proceedings, Second Sanitary Engineering Conference, RADIOLOGICAL ASPECTS OF WATER SUPPLIES,* 80 pp., $2.00 per copy.

Circular 70, *Engineering Departmental Reports and Theses, 1960,* 48 pp., free of charge.

Publications 1904-1960 University of Illinois Engineering Experiment Station. New revised edition of Experiment Station publications catalog, free of charge.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 2, No. 7, SEPTEMBER 1961

ENGINEERING RESEARCH AT ALL TIME HIGH: ECRC

The University of Illinois is among the top three U. S. universities in amount of engineering college research, according to results of a survey published by the Engineering College Research Council of the American Society for Engineering Education.

The survey lists 11,000 projects in progress in 121 leading engineering colleges with total expenditures of more than $180,000,000 for the last year.

The Engineering Experiment Station of the University of Illinois reported 350 investigations involving annual expenditures of $7,463,000. Of these, 266 are sponsored by agencies outside the University, including 52 federal and state agencies, 35 private companies, 19 industrial associations, and 5 private foundations. This degree of confidence shown by outside agencies in financing cooperative research programs with the U. of I. reflects the outstanding reputation gained by the Station and College of Engineering faculty members over the years.

The results of the survey were published this past summer in the *Engineering College Research Review,* a biennial publication of the Engineering College Research Council. The *Research Review* compiles the research projects in engineering at every U. S. college or university with a major research program. The *Review* is distributed for $4 per copy by the American Society for Engineering Education, University of Illinois, Urbana.

ELECTRIC HOME HEATING BOOKLET

Illinois engineers or home owners interested in electric heat will find much helpful information in *Home Heating With Electricity* by Professor H. H. Beaty. This booklet compares electric heating with other types of heating systems and briefly discusses the various types of electrical heating units, along with tips on proper installation. It also gives information on insulation requirements and techniques, including recommendations on vapor barrier installation and adequate ventilation procedures. It is not a report on a specific research project, but rather a summary of information to help the consumer make some basic decisions about heating. Single copies are available free of charge from the Office of Information, Mumford Hall, University of Illinois, Urbana.

HIGHWAY TRAFFIC SAFETY CENTER

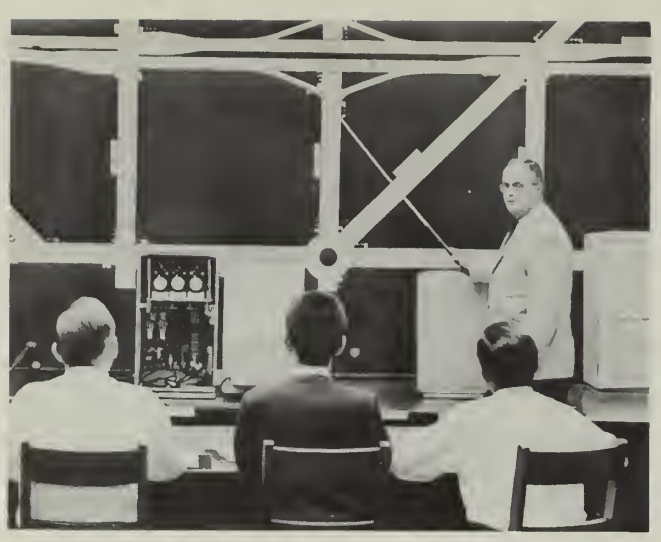
Suppose a town about the size of Albany, New York, were struck by disaster — about a quarter of the population killed and the rest injured. The entire nation would be shocked into mourning for the more than 38,000 dead. Relief would be rushed from all corners of the continent for more than 100,000 injured. It would be considered a national tragedy. Also if much of the tragedy might have been avoided, a major effort would be made to keep such a catastrophe from happening again.

A disaster of the magnitude of our hypothetical example happens in this country every year; not in one place but sprinkled over our highways and streets from coast to coast as automobile accidents. These thousands need not die.

The human cost of automotive transportation, in lives and suffering, can be lowered by research and training. With this aim, the Board of Trustees of the University of Illinois on August 10 approved establishment of a Highway Traffic Safety Center at the University.

In 1958 the Division of Traffic Safety of the Illinois Department of Public Safety requested the assistance of the University in educational and research programs in traffic safety. University President David D. Henry established the Committee on Utilization of University Resources for Traffic Safety to make recommendations for coordinating the University's resources to this end. Twenty departments of the University were found to be interested in an expanded traffic safety program, and 23 state and national organizations encouraged the establishment of the Center.

The new Center will have three primary objectives:



Professor John E. Boerwald, director of the new Highway Traffic Safety Center, also teaches courses in traffic engineering at the University of Illinois. The traffic engineering program is an area of specialization in civil engineering which trains students in the concepts of traffic characteristics and control.

coordination of traffic safety teaching and research; provision of a channel for financial support for training and research; and assistance in the use of traffic safety information. It will accomplish these objectives through formal education, extension education, research, and information services. The activities of the Center will be primarily in departments already existing on the campus.

Chairman of the Committee that developed plans for the Center was A. E. Florio, Professor of Safety Education. Engineering faculty members who were active in the Committee's work were Ellis Danner, Professor of Highway Engineering, and John E. Baerwald, Professor of Traffic Engineering. The highway and traffic engineering activities of the Civil Engineering Department are expected to play major roles in the activities of the Center.

The new Traffic Safety Center will be in the College of Engineering. Professor John Baerwald was named Director by the Board of Trustees when they established the Center. Professor Baerwald heads the traffic engineering group in the Department of Civil Engineering.

A total of 1,725 people died on Illinois highways in 1960. At the normal rate of increase in the number of vehicles on our highways, even if the death rate per hundred million vehicle miles can be held to the present 4.6 level there will be 2,590 people dying on Illinois highways each year by 1970. Reduction of this death rate poses a real challenge to the new Center and to similar state traffic safety centers throughout the nation.

MATERIALS THAT CREEP

The engineer designing a load-carrying member must know the properties of the material and how to use them best. Design procedures for creep have become an increasingly important part of the engineer's work in this area.

Engineering Experiment Station Bulletin 460, *Theoretical and Experimental Analyses of Members Made of Materials That Creep,* gives the engineer procedures and data that should help him deal with the creep problem in design. The new bulletin is by O. M. Sidebottom, G. A. Costello, and S. Dharmarajan of the University of Illinois Department of Theoretical and Applied Mechanics.

Bulletin 460 has three basic purposes. First, it presents a theory for predicting curves for beams, centrally loaded columns, and eccentrically loaded tension members and columns, based on the arc hyperbolic sine curve representation of the isochronous stress-strain diagram. Second, it brings together the results of several experimental investigations comparing theoretical and experimental load-deflection curves for metal members at elevated temperatures and for plastic members in a controlled atmosphere room. Finally, it considers the suitability of using a modified secant formula for predicting the collapse loads and the maximum deflections of eccentrically loaded columns made of materials that creep.

Bulletin 460 is available from Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, for one dollar per copy.

THE JUNIOR ENGINEERING TECHNICAL SOCIETY

How can a high school student interested in engineering learn enough about the field to know which type he wants to study in college? One way is through JETS, a nationwide organization, sponsored by the Engineers Council for Professional Development and a group of industries and universities to stimulate interest in science and engineering among high school students.

JETS, the Junior Engineering Technical Society, was started in 1950 at Michigan State University. Today there are JETS clubs in high schools in almost every state. These clubs provide opportunities for the students to work on engineering projects. Club activities aid each student in appraising his own abilities and in learning what engineering is all about. Although there is no cost to the student for membership in JETS, the organization offers awards each month for the completion of outstanding engineering projects by its student members.

All JETS clubs can get material from the organization's library, and films and literature are circulated to keep members aware of current happenings in engineering. Some of the clubs sponsor scholarships for their members, and four major conferences are held each year to show and compare projects, exchange views, and to make awards to project winners. As of June, 1961, there were 825 official JETS chapters in 45 states and seven foreign countries. The organization is officially recognized by all major technical societies in the U. S.

Although the State of Illinois already has a number of JETS chapters, the movement is now receiving statewide coordination. Mr. David Reyes-Guerra of the U. of I. General Engineering Department has been appointed the State Director, and he will be in charge of JETS activities and programs throughout Illinois. While the University of Illinois will cooperate with JETS in Illinois activities, there is no direct affiliation between the Society and the University. For further information write: Mr. David Reyes-Guerra, 313 Transportation Building, University of Illinois, Urbana, Illinois.

People outside the State of Illinois, who desire information, can write to the JETS National Offices, United Engineering Center, New York, New York.

ROVING RABBITS AND RADIO

Where does a rabbit go after dark? A talking rabbit would probably indignantly say, "none of your business," but two University of Illinois scientists have discovered a way to find out without incurring bunny's wrath.

An electrical engineer and a natural scientist have been keeping midnight tabs on rabbits and other wildlife via radio. They have built tiny radio transmitters weighing less than an ounce that can be strapped to an animal's back. A built-in battery keeps the transmitter going for as long as four months. Once equipped with the lightweight transmitting harness, the animal is tracked by a direction-finding radio. On ducks flying a half-mile high the radio can be heard for 60 miles, while on ground animals it has a half-mile range.

The button ot the top of this robbit's horness is o rodio transmitter with a built-in bottery which will operote continuously from one to four months for tracking studies being made ot the University of Illinois. The radio's antenna is in the plostic belt. The initialled ear tog identifies the onimol visually.

Research at the U. of I. has already brought new information on the habits of the busy rabbit. Earlier studies had indicated that a wild rabbit seldom ventured farther than the 6- to 8-acre area of his home range. Radio tracking has revealed, however, that in a single night a rabbit often confines his activities to a 2-acre area. With the new device U. of I. investigators have found that

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☐ Bull. 460, *Theoretical and Experimental Analyses of Members Made of Materials That Creep,* O. M. Sidebottom, G. A. Costello, and S. Dharmarajan. *One dollar.*

☐ Circular 69, Proceedings, Second Sanitary Engineering Conference, *Radiological Aspects of Water Supplies. Two dollars.*

☐ Circular 70, *Engineering Departmental Reports and Theses, 1960. No charge.*

☐ Reprint 62, *Progress Reports of Investigation of Railroad Rails,* Ralph E. Cramer. *Fifty cents.*

☐ *Careers in Engineering,* a guidance brochure for high school students. *No charge.*

the rabbit can't cover as much territory as formerly supposed. He awakens around 5 p.m., eats, and starts his night-time rounds. About 7 a.m. he heads back for bed — completely unaware that radio has revealed his every move throughout the night.

REACTOR "PULSING" PERMITTED

A new dimension is being added to nuclear engineering at the University of Illinois this week. Professor Ross J. Martin, Director of the Engineering Experiment Station, has announced that the College of Engineering's TRIGA nuclear reactor is beginning to "pulse" up to a power level of 250 million watts. The University of Illinois is the only university presently permitted by the AEC to do this. Permission to pulse the reactor was granted by AEC earlier in July.

The reactor has been operating at levels up to 100,000 watts since August 16 of last year according to Professor Martin. He said the pulsing capability was made possible by a grant to the University of more than $51,000 by the National Science Foundation for special fuel and control instrumentation.

The fuel is of a special design made by General Atomic Division of General Dynamics, San Diego, California. The nuclear characteristics of the special fuel automatically end the pulse. The entire pulse takes less than one second.

According to Dr. Marvin E. Wyman, Professor of Physics and Nuclear Engineering, pulsing the reactor gives it some of the research capabilities of much larger and more expensive installations. Dr. Wyman said that the full research possibilities of pulsing will not be known until more work has been done on it.

Dr. Wyman emphasized that although the reactor operation is in terms of watts, the reactor is not used to produce power. "TRIGA is used for teaching in our nuclear engineering program and as a research tool," Dr. Wyman said. "Departments from all parts of the campus use it as a source for radiation in a wide variety of research programs, and of course we can use it to learn many things about reactor design and operation."

In the jargon of the nuclear engineer, the Illinois TRIGA is allowed to have "two dollar" pulses. A "pulse" is a rapid, brief increase in the power level of an operating reactor. A "one dollar" change in reactivity is the amount of fuel that has to be added to a reactor operating at a steady power level to permit a chain reaction with just the "prompt" neutrons. This means that rapid changes in power levels are possible. The Atomic Energy Commission granted the University of Illinois' reactor permission to "pulse" up to twice this level, or "two dollars" worth.

Dr. Wyman explained that the pulse is not achieved by suddenly adding more fuel to the reactor, but rather by removing some of the "poison" or neutron-absorbing material from the fuel already present. This is done, Dr. Wyman said, by literally "blowing" a control rod out of the reactor core with compressed air.

The University's nuclear engineering program in the College of Engineering offers only graduate degrees at the master's and doctoral levels. The research program with the reactor is expected to expand greatly in the next few months with the addition of the pulsing capability.

Editor: R. Alan Kingery

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 2, No. 8, OCTOBER 1961

FALL ENROLLMENT FIGURES

Approximate registration figures for the fall term show the total University student population on the main campus at Urbana to be 23,000. The entire University registration, including the Chicago Undergraduate Division and the Chicago Professional Colleges, is now around 33,000. Of the Urbana total, approximately 3700 are registered as engineering undergraduates and 1200 as engineering graduate students.

The large graduate enrollment is primarily the result of the outstanding graduate education and research program at the U. of I. In the past seven years the number of doctorate degrees conferred by the University of Illinois in all engineering fields has been exceeded in total by only one other institution in the nation.

ENGINEERS, EDUCATION, AND ENCOURAGEMENTS

College teaching can pay an engineer almost as well as work in industry, and in either field a graduate degree is like money in the bank. These are two of the conclusions which can be drawn from a salary survey of U. of I. engineering graduates of 1956 recently made by the College of Engineering placement office.

The survey covered only people who received B.S. degrees five years ago. Of the people surveyed, those who now have advanced degrees have earned them since 1956. Nevertheless the survey showed that the attainment of an advanced degree is still a good investment in time and money. In spite of being in graduate school rather than on full-time jobs for three or four years, the men who have earned Ph.D.'s since 1956 are now earning over $200 more per month than men in the same areas of work who stopped their education with bachelor's degrees.

It shows the over-all average monthly salary of the graduates of 1956 to be $747.39; while the average for the college teachers involved was $723.12, and none of them had yet reached a rank higher than assistant professor. The teachers, who have all taken graduate study during these years, have less "time on the job" than the others surveyed. It looks as if engineers in the future will receive more encouragements to go into the teaching profession than the traditional "satisfaction involved in helping shape the minds of the young."

$82,000 GRANT FOR POLLUTION STUDIES

Professor John E. Pearson of the General Engineering Department has been awarded an $82,000 grant for a three-year study related to air pollution problems from the National Institutes of Health, U. S. Public Health Service.

The study, to be administered by the Department of General Engineering, will concern the rate of transfer of radon gas from the ground into the atmosphere. Radon, a radioactive gas caused by the decay of the small amounts of radium in nearly all soils, may be used as a tracer to give information about materials in the atmosphere which cause air pollution.

Such a study is important because some of the material in the atmosphere comes from automobile exhausts, and this problem is becoming acute as cities grow along the highways. "Strip cities," such as the one growing between Boston and Washington, D. C., are faced with serious air pollution problems.

The University of Illinois study will consist of measuring the radon as it comes out of the soil. Measurements will be taken in various parts of Illinois and elsewhere in the Midwest. Comparisons will be made of the rate it comes from equal areas in different locations at different times of year.

Professor Pearson, who holds degrees in mechanical engineering and meteorology, has done similar work for Argonne National Laboratories in Argonne, Illinois. He will be working with Argonne on a cooperative basis as this project develops.

Here o structure is being erected by ogriculturol engineers on the University form from precost concrete footings, rigid fromes, ond woll ponels with exponded polystyrene cores for insulotion. The fromes ore mode in three ports ond bolted ot o scorf joint locoted ot o point of theoreticol zero moment. Such precost concrete building fromes con provide interiors free of supports, trusses, ond broces like the lumber rigid fromes described in the June, 1961, *Engineering Outlook*. A complete reseorch report will be onnounced in these poges when it is ovoiloble for distribution.

ENGINEERING RESEARCH IN THE 60'S

Research in U.S. engineering colleges should triple in the 1960's, if research keeps pace with graduate study. This was the prediction of Ross J. Martin, Director of the Engineering Experiment Station of the University of Illinois, speaking on September 5 to the Second International Conference on Fundamental Research on Plain Concrete.

Professor Martin predicted to the 100 conference participants from seven countries that "the next ten years will see a growth from the current rate of $130,000,000 per year to approximately $400,000,000 per year" in U. S. engineering college research.

In making his prediction, Martin cited figures showing a correlation between number and levels of graduate degrees awarded and dollar volume of research in engineering schools. Since research by both faculty and students is a vital part of graduate education, the correlation can be expected to continue.

Commenting on industry's role, Martin said, "Over the past ten years direct research support from industry has remained essentially constant while that of government has more than tripled. If this process takes place again over the next ten-year period, we will find an even smaller percent of industry support and a greater dominance of government support in our research sponsorship — already representing 85 percent of sponsored research support. Industry is losing a fine opportunity to keep in direct touch with our professors and graduate students by failing to carry their normal share of engineering college research support."

Martin said that government, on the other hand, has moved vigorously into university research sponsorship. "And while our relationship with government has not been entirely free from occasional attempts at benevolent dictatorship, the pattern of cooperation has in general provided full freedom of the university to conduct a productive program of high quality research."

Martin's remarks were made in his welcoming address as the Second International Conference on Fundamental Research in Plain Concrete began at the University's Robert Allerton House conference center. This four-day conference, like the first conference at Illinois in 1958, not only presented results of research but also discussed current technical knowledge in related scientific fields pertinent to the study of concrete.

Participants included men in physical chemistry, physics, geology, petrography, and rheology, as well as engineers. The meeting was supported by the National Science Foundation and sponsored by the American Society of Civil Engineers, the American Concrete Institute, the Reinforced Concrete Research Council, the Portland Cement Association, the American Society for Testing Materials, and the University of Illinois.

NEW EDITOR FOR STATION

Paul T. Bryant, editor of the *Journal of Engineering Education* and assistant editor for the Engineering Experiment Station since 1958, was named editor for the Engineering Experiment Station at the beginning of the current academic year. He succeeds Professor E. C. McClintock, who has moved to full-time teaching duties in the technical writing program of the Department of General Engineering. Bryant will continue as editor of the *Journal of Engineering Education,* the official publication of the American Society for Engineering Education. ASEE has it national headquarters on the U. of I. campus.

ENGINEERING CAREERS BOOKLET

The sixth edition of *Careers in Engineering,* a guide for people considering enrollment in engineering school, has just been published. It describes the various areas of engineering, the kinds of engineering positions, and the objectives of the engineers' college education. It lists the departments of the U. of I. Engineering College and gives information about the work and programs of study in each. The booklet also contains material about various facilities, honor societies, and extracurricular activities available on the U. of I. campus. It is available, free of charge, from Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana.

WHY DOES A CULVERT CROSS THE ROAD?

Each year over one billion dollars is spent on the construction of culverts and these unobtrusive structures take 15 to 25 percent of the highway maintenance dollar. In fact, there are so many culverts in modern highway construction that their total construction cost exceeds the total costs of large bridges.

Culverts cross the road, of course, to get water to the other side — and they must be the proper size to do the job. If too big, they raise costs. If too small, they cause floods. Determining this size is a complex problem. It involves such uncertainties as the amount of rainfall and various types of soils and their runoff conditions. In the past the engineer had to make such decisions from his own judgment based on past experience. Now a method of determining culvert sizes which minimizes such "educated guessing" has been developed by Professor Ven Te Chow of the U. of I. Civil Engineering Department.

The method was described by Professor Chow in a talk before the 10th annual Hydraulics Conference of the American Society of Civil Engineers on the Urbana campus in August. The new method is primarily based on scientific knowledge of the water runoff speed on various types of soils and other surfaces. This information has been put into a design chart for easy use by engineers. Professor Chow's method will have many advantages over the Talbot Formula, a method currently used for most present culvert computations and proposed 74 years ago by another U. of I. professor, A. N. Talbot. The new method promises great savings in highway and maintenance costs, as well as in farm drainage programs and flood protection work.

Professor Chow's talk will be reprinted in the *Journal of Hydraulics Division, Proceedings of the American Society of Engineers.* The entire theory, including supporting data, pertinent hydrological information, design charts, and two bibliographies, is in the process of publication as an Engineering Experiment Station bulletin.

THE ENGINEERING ALUMNI COMMITTEE

The activities of the U. of I. Engineering Alumni Committee are getting a boost this fall by the addition of eight new members, seven from Illinois and one from Indiana. They are C. P. Atkins, Champaign; A. R. Ayers, Bement; G. L. Crawford, Collinsville; J. W. Haas, Pittsfield; C. J. Laegeler, Libertyville; H. Roffmann, Salem; G. K. Wineland, Peoria; and E. A. Koertge, Indianapolis, Indiana.

The Engineering Alumni Committee is a group of engineers who voluntarily work with secondary school administrators and teachers in telling students about career opportunities in engineering. It is not the Committee's purpose to recruit students for the University of Illinois, but rather to provide the best counsel to graduating seniors who are qualified to enter the engineering profession.

The annual Alumni Committee meeting this year will take place November 3 and 4 on the Urbana campus. In addition to other topics to be discussed, the members will be given information on the policies and future plans of the Junior Engineering Technical Society (see *Engineering Outlook,* Sept., 1961). As this program develops, the Committee will work closely with the JETS organization in a coordinated program of career information for prospective college students.

FALLOUT SHELTER STUDY

Thousands of public buildings in this country could be used as shelters in the event of nuclear attack, but no evaluation has yet been made to determine which ones could withstand radiation and blast damage. The Department of Defense has announced that such a selection will be undertaken as soon as enough engineers can be hired and trained to do it. Due partly to the past studies of nuclear blast resistant structures of the U. of I. Civil Engineering Department, the U. of I. has been chosen as one of the schools to teach engineers how to make such evaluations.

The first of seven two-week short courses started on October 9, 1961. Altogether there will be 200 to 250 trainees, architects, and engineers selected from various firms from several midwestern states. The selections are made by the Division Engineer of the Corps of Engineers, North Central Division, Chicago, Illinois. Mr. J. T. Hanley of the Civil Engineering Department, who has attended a pilot course at Fort Belvoir, Virginia, is in charge of the program at the U. of I.

A GUILD OF SCHOLARS

Medieval guilds brought together highly skilled and expert craftsmen for mutual protection, aid, and advancement of artistic skills. The early guilds fostered a spirit of excellence that continues to be felt today in all fields where superior accomplishment is sought. At the University of Illinois a modernized guild is now in operation.

The Center for Advanced Study was established for "the encouragement of creative achievement and scholarship by providing recognition to scholars of the highest distinction and by providing incentives for the highest level of scholarly achievement." Created by the U. of I. Board of Trustees in the spring of 1959, the Center

consists of individuals who are considered by the University President and the Board to be worthy of special recognition for their study and research. The U. of I. program allows the distinguished scholars admitted to membership to continue in their creative pursuits by having their academic work loads reduced so that they can participate more fully in basic study and research. By offering membership to the most distinguished, most productive, and most widely recognized scholars, the Center helps to keep good faculty members from leaving to work in industry, other universities, or from being channeled into administrative positions where their contributions to higher study and research would be restricted. The Center also helps the University in its continuing efforts to attract outstanding scholars from other institutions to the U. of I.

Two types of membership are conferred by the Center: Member and Associate Member. Members are appointed for renewable five-year terms and receive salaries "comparable to the best professorial salaries in American universities." They retain their departmental affiliation and no change in their duties is required by the Center. However, it is possible for Members to have their teaching loads reduced so that they can participate more fully in basic study and research. Associate Members are appointed for varying periods and may be freed of part or all of their teaching duties except as directors of graduate theses.

Dr. John Bardeen, Nobel Prize winning physicist and a member of the College of Engineering faculty, who himself is a Member of the Center, said in a recent speech: "The Center for Advanced Study helps the University in attracting and keeping an outstanding graduate faculty and in future years should play an increasingly important role in the University."

In addition to Dr. Bardeen, Professor of Electrical Engineering and of Physics, other outstanding and world famous scholars admitted to select membership in the Center include: Dr. Joseph L. Doob, Professor of Mathematics who is well known for his work in the theory of probability, Dr. Reynold C. Fuson, Professor of Chemistry who has made many important contributions to theoretical organic chemistry, and Dr. Julian H. Steward, Research Professor of Anthropology who is noted for his research on Indian cultures and his development of cultural change theory. Among the Associate Members elected for 1961-62 are Prof. D. E. Mapother of the Department of Physics and Prof. A. S. Veletsos of the Department of Civil Engineering.

The Center presently consists of these four full members and ten associate members named for the 1961-62 academic year. A special unit of the Graduate College of the U. of I., the Center is now in its second year of operation. Through its pioneering efforts it has already helped to carry on the tradition of excellence first achieved by the early medieval guilds.

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 2, No. 9, NOVEMBER 1961

TELEVISION FRINGE BENEFITS

Today nearly everyone watches television; some just watch it better than others. "Better" refers to viewers in areas where a number of channels are received with equal clarity. Now there is hope for the others, the people who live in fringe areas that have difficulty getting any channel with ease. One of the many research projects in the University of Illinois Antenna Research Laboratory has been the development of VHF television antennas capable of receiving all VHF channels equally well. Professor Paul E. Mayes and Robert L. Carrel of the Department of Electrical Engineering have jointly invented an antenna which helps to solve that problem. Called a "resonant-V" antenna, the device is superior to other antennas used for long distance TV reception. Most of the old type VHF antennas receive one channel better than others; with the Mayes-Carrel invention all VHF stations can be picked up equally well.

One model of the new antenna has fourteen aluminum rods that are swept forward in a V-shape design. These rods are attached diagonally to two central eight-foot rods which are in turn attached to a supporting pole at right angles to the out-stretched "V" array. The antenna can be mounted on a tower or atop a house and turned in the direction of the television stations it is trying to pick up. The new antenna promises to be useful for viewers in fringe areas that are served by two or more stations in different cities.

In addition to the "resonant-V" antenna for VHF reception, Mayes and Carrel have also designed a UHF and a combination VHF-UHF antenna for balanced reception of stations broadcasting over both kinds of channels.

Patent applications have been made by the University of Illinois Foundation and negotiations are under way to have the antenna manufactured. If you are one of the people who live in an area where reception is poor, you can at least look forward to better viewing in the future when the resonant-V antenna is made available.

STUDIES IN SPACIAL AEROTRIANGULATION

The University of Illinois has become one of eight photogrammetric centers over the world to participate in an international research program on spacial aerotriangulation. Dr. H. M. Karara, Associate Professor of Civil Engineering, is directing the U. of I.'s part in the program.

Aerotriangulation is a photogrammetric technique for providing control over extended areas by measurements on aerial photographs. It has recently assumed new importance because of its usefulness in reducing the amount of ground control required in the production of maps of large areas.

"Ground control" is the use of points established by survey on the ground. This is a time-consuming and expensive process, and in military operations sometimes impossible. By use of aerotriangulation, the number of such ground control points is sharply reduced.

The National Science Foundation has awarded the University of Illinois Department of Civil Engineering a grant of $56,900 for a two-year basic study in this field. Most of the experimental phases of the NSF-supported work will be part of the international research project administered by the International Society of Photogrammetry. The Ohio State University and the University of Illinois are the only two U.S. participants in the program. The others are the Swiss Federal Institute of Technology in Zurich, the Technische Hochschule in Frankfurt, the Polytechnical Institute in Milan, the International Training Center for Aerial Surveys in Delft, the Canadian National Research Council in Ottawa, and the National Geographic Institute in Paris.

A major part of the study will be focused on the "cross-bases" method, a relatively new technique of aerotriangulation developed by Professor Karara in 1955 at the Swiss Federal Institute of Technology in Zurich. During the last four years, this method has been the subject of research under the sponsorship of the University of Illinois Research Board.

Ward R. Malish (right) of Henry, Illinois, winner of the 7th C. C. Wiley Award at University of Illinois, tells Professor Wiley about the 6,500-mile trip through 13 states and the District of Columbia to gather data and pictures on current highway work. The award honors Professor Wiley, pioneer in traffic engineering, who retired in 1952 after 46 years on the University staff. Information and photos brought back by Malish will be used by the University's Civil Engineering Department.

THE REAL MEN BEHIND THE MISSILES

This is the first time an article from another publication has been reprinted in *Outlook,* but this statement by E. C. Easton, Dean of Engineering at Rutgers University, published in the latest issue of *Engineer,* deserves wider circulation among non-engineers. Mr. Easton says something which has needed to be said for a long time . . .

BUT FOR THE ENGINEERS ASTRONAUTS ARE NAUGHT

Recently the names of Gagarin, Shepard, Grissom, and Titov were featured prominently in the American press. All four had been passengers in vehicles designed, built, and operated by others. Despite their relatively passive roles in their respective adventures these men were hailed and feted as though each had performed the miracle of space-flight single-handedly. There was an editorial in The New York Times *after Shepard's flight in which Shepard and even the astronauts who were trained, but did not make the flight, were given credit. Such reporting reveals an alarming ignorance of the area of responsibility for technological advances.*

Let us have at least a faint cheer for the engineers who designed, built, launched, and controlled the vehicle in which these space passengers rode. Let's be sure that the public knows that the real heroes were engineers, not scientists or astronauts. The scientific principles which govern space flight are few and simple. The engineering applications of those principles to accomplish a successful flight are incredibly complex.

An engineer told Shepard exactly what to expect at every instant of that flight. He told Shepard that he would experience so many G's within 15 seconds; that, at such a time, the periscope would come down; that, at a given time, the rotating rocket would fire and that, at another specified time, the retrograde rocket would fire.

The exciting thing is that someone on the ground, an engineer, was able to predict this before the rocket was fired. Furthermore, Shepard had in front of him a little globe on which the position of that capsule was located at every instant, and on which there was an arrow pointing to a landing place, if Shepard were to push the retrograde rocket button. How is it possible to design a thing that will tell a man in a tumbling space vehicle exactly where he is at any instant of time? This ability to design a complex vehicle and to predict its performance before it leaves the ground is the most exciting feature of space flight. It is the most sophisticated talent ever possessed by the human race and it is the mark of the engineer.

PARTNERS IN RESEARCH

Research cooperation between universities and industry can pay big dividends for both, each in its own coin. Industry can gain new products and techniques, and universities can strengthen research and teaching programs without lowering academic standards. This was the picture presented by Dean W. L. Everitt of the University of Illinois College of Engineering, speaking at the National Electronics Conference in Chicago on October 11.

A prominent researcher and educator in electronics, Dean Everitt spoke specifically of the electronics industry in the Midwest, but he offered his views as applying generally to university-industry cooperation. For the Midwest, he pointed up the need for more such joint effort. The University of Illinois, he said, is doing research in electronics and related areas at a rate of more than $5,000,000 a year. Industry in the region, however, is not matching that level of research activity. He urged industry to increase its research activity and interest, and he outlined ways in which industry could work effectively with universities of the region on common problems.

"To cooperate effectively with a university," he said, "a private company must understand the nature of the academic community." Referring to the university as "a community of scholars," Dean Everitt said: "Most of the companies in the electronic field which are expanding significantly are also places of learning. To interact properly with universities, industry can, and must, itself be-

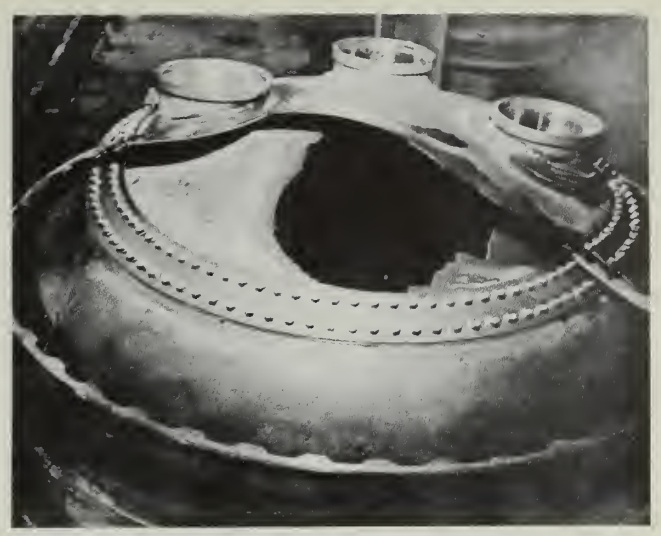
come a part of the community of scholars." One way to accomplish this, he said, would be for industry to locate advanced research and development facilities in close physical proximity to the universities. This would provide the industry research staffs with intellectual development and stimulation that cannot be done away from a campus, allow them to attend the seminars which take place on the campus, and provide better opportunities for university members to serve as consultants to industry and industry staffs to serve as consultants to the university.

Finally, Dean Everitt recommended that industry adopt the university's custom of allowing its staff members to take sabbatical leaves to visit and work with other institutions. "Should not industry," he asked, "provide leaves, with pay, for their research engineers to participate in the more basic and advanced research which is characteristic of the university, or in some cases even at other industrial research laboratories?" He also suggested that industry should cooperate with the universities in providing their employees with the opportunity for advanced education in residence on the university campus. Dean Everitt closed with the statement that such a harmonious relationship between the universities and industry would be possible and mutually beneficial if both sides looked upon themselves as partners striving for a common goal.

TREMENDOUS TRIFLES — IT'S THE LITTLE THINGS THAT COUNT

Failures of missiles, buildings, ships, and bridges are often dramatic, sometimes catastrophic, and always educational. The explosion of a missile at launch is particularly dramatic and, at best, carries a suggestion of catastrophy by pinpointing a weakness in our defense system. When the remains are pieced together, the investigators may decide that a microscopic flaw, greatly expanded by the pressures of firing, was the cause of failure. The education comes from learning why the flaw existed and how it caused the failure. The prediction and prevention of such brittle fractures of metals is one of the current aims of the Fracture Research Laboratory in the University of Illinois Department of Theoretical and Applied Mechanics.

Research on how to construct a reliable motor case for solid-propellent missiles is directed by Professor H. T. Corten. The solid fuel in a missile such as the Polaris is carried and burned in a container called the motor case. The case itself is dead weight as far as missile performance goes, but it must be strong enough to withstand the high pressures involved in liftoff. The problem is how to make a motor case which is both light in weight and structurally reliable.



The large rupture in this racket motor case resulted fram a flaw which was impassible ta detect before testing. One af the faur exhaust ports has been blown away entirely by the test pressure.

Motor cases are fabricated by welding sheets of high strength steel together; failure occurs by catastrophic fracture which begins with tiny flaws, frequently at the welds. Until recently the motor cases were tested for reliability by stressing them twice to the pressure anticipated during the firing of the missile. University researchers found that this testing procedure actually damaged the motor cases by increasing some of the flaws to near critical size, making the motor case unable to withstand the pressures of actual firing.

To remedy this, the engineers devised an improved procedure: a single test in which a pressure approximately 10 per cent higher than the firing pressure was imposed. This test singles out the motor cases with flaws of critical or near-critical size, but does not damage the remaining cases so they will rupture on the firing cycle.

In addition to motor cases, other rocket and aircraft structural components offer metal fracture problems, especially when they are made of the so-called refractory metals such as tungsten, columbium, chromium, and molybdenum. The mechanical behavior of these materials under extreme rates of loading and temperature is being studied by a group under Professor G. M. Sinclair. One advantage of refractory metals is that they retain their strength at high temperatures. An experimental aircraft, the X-15, recently flew 3,900 miles an hour; at that speed, the temperature of the leading edges of the wings was about 1,500° F. The ability to withstand such extreme conditions will give refractory metals widespread use in the future.

But these materials, like most other things in this world, have their drawbacks: for example, many of them

become "brittle" and fracture easily at low temperatures. A plane with parts of tungsten or molybdenum could withstand the high temperatures of flight but the metal might fracture at the ordinary temperatures of takeoff. The "low" temperature at which these metals become brittle varies with the metal and is influenced by factors such as stress, temperature, and impurity content.

Results of the work to date suggest that a reasonably accurate mathematical description of the flow and fracture characteristics of such metals can be worked out. An equation describing the behavior of columbium in terms of the variables has already been developed. Such mathematical descriptions will make possible the prediction of the behavior of metals at low temperatures and will indicate methods of fabricating materials which will withstand the extremes of temperature and stress.

Fracture research has fundamental as well as practical significance. It contributes to the general knowledge of the behavior of metals, bringing forth results that are applicable to the use of metals in buildings, bridges, industrial machines, and consumer goods. Today, the "back to the old drawing board" philosophy of the past is fast disappearing; making progress by making mistakes is giving way to the scientific prediction and prevention of the calamities that result from metal fracture.

PHOTOGRAMMETRY SHORT COURSE

A short course on Photogrammetry and Photo-Interpretation will be conducted at the University of Illinois January 30 through February 2, 1962. Civil Engineering Professors H. M. Karara and T. H. Thornburn will be in charge, respectively, of the two portions of the course. The course, administered by the Civil Engineering Department in cooperation with the Division of University Extension, will be so conducted that beginners as well as professionals can benefit from it. For full details please contact: Supervisor of Engineering Extension, Room 116d Illini Hall, University of Illinois, Urbana, Illinois.

FOURTH SANITARY ENGINEERING CONFERENCE

Water distribution systems will be the subject of the Fourth Sanitary Engineering Conference to be held on the University of Illinois campus in Urbana on February 13 and 14, 1962. The conference is sponsored jointly by the Division of Sanitary Engineering of the Illinois Department of Public Health and the University of Illinois Department of Civil Engineering. This conference is designed to be of value to operating and administrative personnel, contractors, and consulting engineers concerned with water supply. Further information may be obtained from Ben B. Ewing, Professor of Sanitary Engineering, University of Illinois, Urbana, or from C. W. Klassen, Chief Sanitary Engineer, Department of Public Health, Springfield, Illinois.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 2, NO. 10, DECEMBER 1961

PARTNERS IN PURE RESEARCH

In the last few years industry has paid increased attention to fundamental research. To some extent this has been caused by the fact that applied research, traditionally the province of industry, is approaching the boundaries of theoretical knowledge, the product of fundamental research in the university. The result has been a trend toward increased basic research interaction between industries and universities where each side contributes what it can do best. A good example of this sort of project is a cooperative study of the fundamentals of superconductivity by the University of Illinois College of Engineering and Fansteel Metallurgical Corporation of North Chicago, Illinois.

Superconductivity, which was discovered fifty years ago, can be most simply defined as the disappearance of all electrical resistivity in certain metals at temperatures near absolute zero (−459° F.). Metals which exhibit this phenomenon are called superconductors. Some of the better known ones are niobium, lead, tin, mercury, aluminum, tantalum, and vanadium. Most superconducting metals (except aluminum) are not particularly good conductors at normal temperatures; most metals which are ordinarily good conductors, such as copper, silver, or gold, do not become superconductors at any temperature. For reasons not yet fully understood, the electrical resistance of superconducting metals drops to less than 10^{-15} of its normal value when the metal attains the superconducting state. Electric currents then apparently flow forever.

Applications are not the primary concern of researchers working on this project, although superconductivity shows much promise in such areas as electromagnetism, the creation of magnetic fields to contain thermonuclear plasmas, and the efficient transmission of electricity. The Fansteel Corporation is interested in the potentialities of superconductors but is aware that fundamental, rather than applied, research is needed to solve the problems now restricting these applications. In joining forces with the University of Illinois, the Fansteel Corporation makes available its knowledge and ability to produce superconductor materials. The University, on the other hand, brings to the partnership its excellent cryogenic laboratory and a group of outstanding research specialists. The laboratory has facilities for cooling these materials to within a few hundredths of a degree of absolute zero. The specialists in the field of superconductivity include Dr. John Bardeen of the Physics and Electrical Engineering Departments, Dr. J. R. Schrieffer of the Physics Department, and Dr. C. B. Satterthwaite of the Coordinated Science Laboratory. Dr. Bardeen and Dr. Schrieffer are eminent authorities in this field who, in conjunction with Dr. L. N. Cooper, authored the fundamental theory of superconductivity which underlies much of the work now being done in the field. Dr. Satterthwaite conducted fundamental research in this area at Westinghouse before joining the University's Coordinated Science Laboratory.

According to Dr. Satterthwaite, this venture of planned cooperation in basic research between the U of I and Fansteel is the kind of partnership between universities and industries that will cut the fundamental Gordian knots that always stand in the way of practical engineering applications.

ACROSS THE STREET AND INTO THE IONOSPHERE

The ionosphere, the protective shield of gases surrounding our planet, burns up earth bound meteors, absorbs death dealing cosmic radiation, and permits long range radio communication. How many questions are yet unanswered about this electrically charged region is suggested by the recent ionospheric rocket probes and by satellites like Explorer VIII. Another indication of the interest in the ionosphere and in basic gaseous research is a recent $60,000 facility grant by the National Science Foundation to the University of Illinois Electrical Engineering Department to apply to the construction of a $187,000 Gaseous Electronics Laboratory. This new facility will permit more effective use of the group's half-million dollar annual research budget.

Because scientists and engineers can't conveniently conduct prolonged experiments in the ionosphere, all possible work should be done on the ground. Most of the attention of the University of Illinois group is now being placed on electromagnetic wave interaction techniques, high-temperature plasma studies, and other areas of gaseous electronics, but an important element of their work is understanding more about the nature of gaseous matter similar in make-up to the earth's ionosphere.

Researchers in the University of Illinois Gaseous Electronics Laboratory have always been interested in "space" — in fact, one of their most pressing problems has been a lack of it in their own laboratories. Next spring, directly across the street from the present engineering campus, they will have a building that will solve most of the ground level "space" problems and will aid them in their efforts to answer the many questions raised about space far above.

Mr. David Reyes-Guerro, Instructar in Generol Engineering and Illinois state directar for the Junior Engineering Technical Saciety (JETS), paints out locotions of Illinois JETS chopters and scenes of other 1960-61 University af Illinais engineering octivities in Illinois ta Dr. Richard T. Fallan of New York City, Executive Director of the JETS program. Bath men spoke on state and national activities of JETS ot the Engineering Alumni Committee Annuol Meeting, November 3 and 4.

BULLETIN 461 AVAILABLE

Engineering Experiment Station Bulletin 461, *Effect of Heat Treatment and Chemistry on the Properties of Low Density Iron Base Sinterings,* by D. H. Boone and E. J. Eckel, is now available for distribution. Steel parts of controlled porosity and accurate shape can be produced by compressing and heat treating iron base powders. This bulletin deals with an evaluation of the variables associated with the development of high strength and ductility in low density parts. A common use for the internal porosity involves impregnation of the parts with oil for lubricating purposes. The price of the 40-page bulletin is one dollar per copy.

A CERAMIC ENGINEER BY ANY OTHER NAME . . .

There are as many definitions for engineering as there are people to make them. The various branches of engineering are even harder to characterize accurately, and ceramic engineering is perhaps the most difficult field of all to describe with precision. This has been one of the jobs undertaken by the High School Science Adviser Program, a project set up three years ago by the University of Illinois Department of Ceramic Engineering to assist Illinois high school science advisers in counseling their students.

On the Science Adviser Program's third anniversary, Dr. A. L. Friedberg, director of the project since its inception in 1958, said: "The success of this program must be attributed to the excellent cooperation of the science advisers of Illinois high schools. Although these are busy people, they have taken their time to give us the names of high school students who have indicated an interest in ceramic engineering and are qualified to enter engineering college. After receiving these names we have contacted each student, offering him information about ceramic engineering and inviting him to visit us. The program has been responsible in large measure for our increase in enrollment in the last three years."

Dr. Friedberg also said that one of the most interesting aspects of the Science Adviser Program is attempting to tell the high school students and their advisers what really characterizes ceramic engineering. "Today different people see the field in many different ways," he said, "depending on their own particular relationship to it. Ceramic engineers and researchers work in many diverse areas. To many of those familiar with the field, ceramic engineering means the product areas of large industries such as glass, cements, refractories, structural clay products, whitewares and porcelains, and ceramic coatings; but today ceramic materials are used for many new applications such as the fabrication of nuclear reactor fuel, coatings for rocket nose cones, electronic compo-

nents, and special refractories to contain the ultra-high temperatures of modern manufacturing. The ceramic engineer is directly responsible for the development of this broad field of engineering and its relationship to other disciplines."

Ceramic engineering is an occupation with a thousand names and a thousand faces. It is generally defined by University of Illinois ceramic engineers as "the field of application of non-metallic, inorganic materials that are related to high temperatures, either in their processing or their uses." It is keeping pace with so many disciplines, they point out, that it would be an injustice to define it more specifically.

ARE "SAFETY" HELMETS SAFE?

The recently published results of a 1959-60 investigation at the University of Illinois suggests that the "safety" of some safety helmets may be more psychological than real. The tests, conducted by the Mechanical and Industrial Engineering and the Theoretical and Applied Mechanics Departments, have uncovered many faults in eleven plastic and Fiberglas safety helmets now on the market. The helmets tested, each bearing a number, are shown in the photograph. Although federal specifications call for a 40-foot-pound test, a number of the helmets ruptured in much less severe impacts. In no case were more than 40 foot-pounds of energy applied, and yet seven of the helmets were unable to withstand the tests. Three of them (numbers 4, 6, and 10) ruptured after several blows of only 24 foot-pounds of energy. This portion of the study was directed by G. W. Harper, Professor of Mechanical Engineering.

Tests of the helmet suspension systems were directed by C. E. Bowman, Professor of TAM. Only two of the eleven helmets (numbers 7 and 10) were stable when hit from the side. The rest would swing to the side abruptly, bottoming the helmet on the head form. Some of the fasteners which connected the suspensions to the helmets failed in these tests, allowing the helmets to fly off of the headform. Two helmets, numbers 8 and 9, failed in this way, preventing the completion of impact tests.

In the analysis of the design of the helmets, the investigators concluded that abrupt reinforcing ridges on helmets may concentrate the impact stresses on small areas of the shell and cause early fractures; and that helmets with smooth shells or slight ridges are often better designs because they distribute the impact stresses more evenly over the shell.

It appears that a great deal of study is going to have to be done before a safety helmet is produced that is truly stable, ductile, and adequately protective. Until it is,

many construction workers are going to have protection that is more mental security than real safety. However, in recent months several manufacturers have produced modifications of both suspensions and helmet materials that may indicate an effort to meet this need. Although these recent models have not been tested, full test data on the helmets shown in the photo are given in a departmental report available upon request from Prof. G. W. Harper, 234 Mechanical Engineering Building, University of Illinois, Urbana, Illinois.

ENGINEERING SEMINARS AND DISCUSSION CALENDAR

Engineers and others in industry have indicated an interest in participating in engineering seminars and other engineering meetings on the Urbana campus. In response to this interest and to foster greater interaction between the College of Engineering and industry of Illinois and the Midwest, the Engineering Publications Office will begin publishing in January a weekly calendar listing topics, speakers, dates, times, and places of seminars, symposia, and other technical sessions open to visitors.

Copies of the calendar, which will be mailed free, are available upon request from the Engineering Publications Office, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois.

The facilities and faculty of the University of Illinois Department of Aeronautical and Astronautical Engineering are being put to good use by members of the newly chartered Student Chapter of the American Rocket Society. Professor H. S. Stillwell (right), Head of the Department, looks on as Professor S. M. Yen (left), faculty sponsor to the Chapter, discusses a Falcon rocket with two Society members. Robert Spitzer, Chapter Treasurer, supports the nose of the rocket. Beside him stands George Carruthers, Chapter President.

NEW COMPUTER FOR CSL

Research on computer applications by the University of Illinois' Coordinated Science Laboratory has been aided by the arrival of a large, high-speed digital computer made possible by a $990,000 grant from the Department of Defense. The machine selected by CSL is a Control Data Corporation 1604, a transistorized computer with a magnetic core memory capacity of 32,000 words. It is operating in a temporary location near the campus until permanent quarters can be prepared in the main CSL laboratory building.

Like other research organizations, the Coordinated Science Laboratory uses computers as a tool in research calculations. Some of its most notable achievements, however, have been in the development of new computer applications, particularly in the area of real-time decision making.

Beginning its University activities as the defense-oriented Control Systems Laboratory, CSL has done much research on military electronic control systems. Among these projects was the development of automatic threat evaluation and weapons assignment techniques for a Navy tactical data system. Another project in the military application area was a study of relationships and interactions between human and computer control (*Engineering Outlook,* September, 1960).

Today CSL is still supported largely by the three military services, but greater emphasis is being placed on fundamental research, with less orientation toward work with immediate military application. Its computer applications work now includes such projects as the PLATO teaching machine (*Outlook,* April, 1961). The new 1604 will be particularly useful for these projects, as well as for research in such areas as decision making, adaptive control systems, physics of surfaces, and plasma physics.

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AT THE UNIVERSITY OF ILLINOIS

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THE OUTLOOK OF OUTLOOK

This issue of *Engineering Outlook,* the first of Volume 3, seems a good occasion to restate the reasons and philosophy that lie behind the paper. *Outlook* is published ten times a year and is available without charge upon request. It is designed to communicate and interpret what is happening in the University of Illinois College of Engineering to both technical and nontechnical people in this country and abroad. The subscribers are made up of engineers, industry executives, engineering educators, newspaper editors, U of I engineering alumni, and people in various other occupations who are interested in what is happening at the University of Illinois in the field of engineering.

The purpose of *Outlook* is to announce new publications of the Engineering Experiment Station, to report new inventions, discoveries, and research results, to give information about seminars, short courses, and other activities of interest to the public, and to describe new educational policies, techniques, and facilities of the U of I College of Engineering. It is important that this information be published, because the U of I College of Engineering is now second in the country in the size of its undergraduate program, second in the size of its graduate program, and second in the size of its research program. Figures for fiscal 1961 show a more than nine million dollar effort in advanced engineering research. To be effective, the results of this work have to be communicated to others.

Engineering Outlook is published by the Engineering Publications Office, 112 Civil Engineering Hall, University of Illinois, Urbana. Requests for subscriptions, questions about articles, or comments about editorial policy may be addressed to that office in care of the editor. Readers who by accident receive more than one copy should notify this office so that the error can be rectified. Questions or comments about specific research projects reported may be directed to the investigator named in the article. The support and encouragement given the publication in the past by subscribers and the U of I staff members who have contributed material is gratefully acknowledged.

REACHING FOR THE MOON — AND BEYOND

As missiles and space vehicles get bigger and better, their designers are faced with new problems. One set of problems of current importance is in the structural behavior of solid propellants.

Not so long ago solid fuel rockets were relatively small, and they could be built without extensive structural analysis. As they grew to the size of Polaris and Minuteman, the propellant became more than just a fuel load. Such large solid propellant grains had to be bonded directly to the motor casing. The bonding and the size created a host of new structural problems.

During storage the vehicle is exposed to various temperatures, which cause the casing to expand or contract and impose large loads on the propellant. Further, since propellants are flexible rubbery materials that creep (inelastic deformations with time), they may deform to such an extent as to impair their normal operation.

In flight, while the fuel is burning, it is under high pressure and acceleration, but solid propellants, with a consistency much like a rubber eraser, have very low ultimate tension stresses (less than 100 p.s.i.). This situation may lead to several possible types of failure. One such failure consists of cracking the grains, which can lead to burning along the crack to the motor case wall and cause an explosion.

Professor Harry H. Hilton of the University of Illinois Department of Aeronautical and Astronautical Engineering, with the assistance of Dr. P. N. Murthy, now of the Indian Institute of Science in Bangalore, is directing fundamental theoretical structural research on solid propellant grains. The work is under a consulting contract with the Aerojet-General Corporation of Sacramento, California.

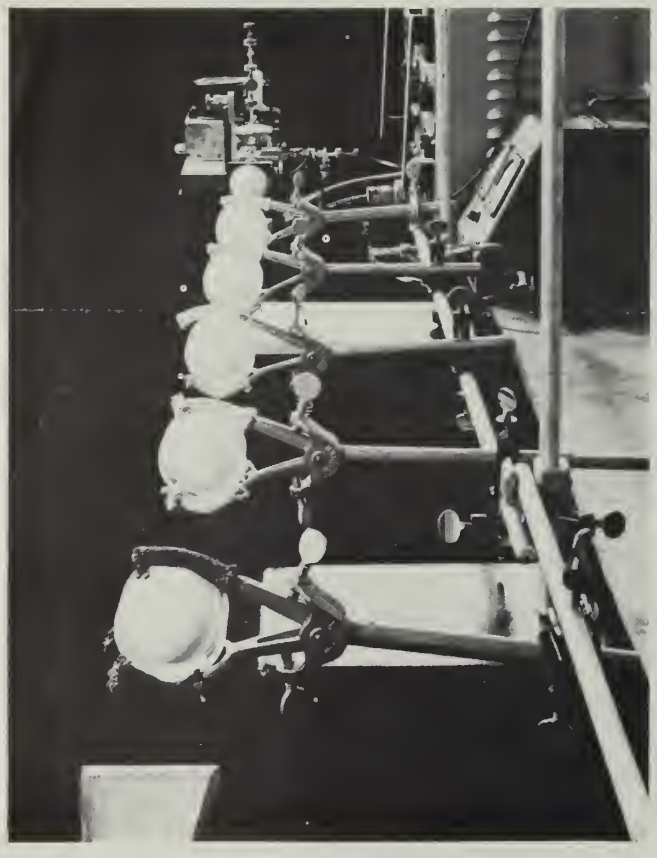
Under Dr. Hilton's direction, analytical studies have been made for short length cylindrical elastic and inelastic grain configurations under various environmental conditions. The inelastic solutions, the first of their kind ever obtained, have been submitted to Aerojet-General for stress analysis and design of very large solid propellant boosters (over 15 feet in diameter and with

more than 1,000,000 pounds of thrust) to be used for manned lunar and space probes.

Other projects under this contract have dealt with the general development of an analysis for solid propellants with different structural properties in various directions, and with the mathematical determination of inelastic material properties. Current solutions now used in the field are based on linear theory; in the next few months, nonlinear theory will be applied to the formulation and solution of large deformations in solid propellants.

Missile failures are costly; there is no room on the launching pad for trial and error. The bigger missiles of the future will be even more expensive, and as manned space flight becomes a reality, not just money but human lives will be at stake. Work of the type being done in aeronautical and astronautical engineering at the University of Illinois will help to save lives and equipment and will hasten the day when the "man in the moon" will have company.

Because of the problems associated with metal waveguides, a beam waveguide using optical techniques is being studied at the University of Illinois as a transmission scheme for submillimeter waves. The balls of styrafoam, shaped like optical lenses, focus radio waves much like optical lenses focus light. In addition to optical techniques, the U of I Ultramicrowave Group, under the direction of Prof. P. D. Coleman, is experimenting with solid state and electron beam interaction techniques to produce waves in the 1/10 to 1 mm. range.



AN EFFORT WE HOPE WILL BE WASTED

In a nuclear war, many lives could be saved if public buildings which offered good fallout protection were marked and stocked with the necessities for survival. In September, 1961, the U.S. Department of Defense asked the Civil Engineering Department at the University of Illinois to conduct a series of two-week short courses on public building evaluation for the Office of Civil Defense. At the end of January the seven courses will have been completed and 245 practicing architects and engineers will have graduated.

Most of those who have attended will take part in the survey of public buildings requested by President Kennedy. All of them were nominated for the course by a District Engineer of the Army Corps of Engineers, a Navy District Public Works Officer, or the Office of Civil Defense.

Although the two-week courses differed from those ordinarily offered by the University and had to be added to an extremely full teaching schedule, the University felt an obligation to take on the additional work because of its high standing in the area of analysis and design of structures to resist the effects of nuclear weapons. Beginning with World War II, the Civil Engineering Department instituted a program of study of the response of structures to blast forces from conventional weapons. In 1948, under the direction of Dr. Nathan M. Newmark, who is now the Head of the Department, Civil Engineering began studies of the effects of nuclear blasts on structures.

Today the U of I Civil Engineering Department is a leader in the field of analysis of the response of structures to high dynamic loads and the properties of materials under rapid strain rates. Most of the work in this area has been sponsored by the Department of Defense and has included participation in nuclear weapons tests. In addition to analytical and experimental investigations, the members of the Department have written a number of manuals for the Army and the Air Force on the design of structures to resist the effects of nuclear weapons. One such manual, "Design of Structures to Resist Nuclear Weapons Effects," American Society of Civil Engineers Manual #42, was written by Dr. Newmark and several other members of the society.

The research program being conducted on the campus, along with the experience of the Civil Engineering Department in the area of nuclear blast resistance, led to the University's selection by the Department of Defense to teach the short course program. Although the program was administered by the Civil Engineering Department, staff members from other departments participated in the teaching. Two hours of lecture on environmental

aspects of shelters were provided by a professor from Mechanical Engineering. U of I nuclear engineers presented six hours of lecture on the structure of matter, the nature of radioactivity, and the biological effects of radiation. In addition, the nuclear engineers held a two-hour laboratory program at the TRIGA nuclear reactor laboratory for each of the classes, demonstrating the fundamentals of radioactive decay and radiation shielding. The remaining class hours were taught by the civil engineers.

The participants who finished the short courses, along with those from similar programs of several other educational institutions, will soon be evaluating and marking public buildings for shelter areas across the country. The result will be a culmination of the cooperative efforts of a number of public institutions — universities and governmental agencies — to provide protection that the engineers hope will never be needed.

STATION ASSISTANT DIRECTOR APPOINTED

John J. Desmond, Assistant Director of the University of Illinois Coordinated Science Laboratory, has been appointed Assistant Director of the University's Engineering Experiment Station. The appointment was announced by Station Director Ross J. Martin.

During this year, Desmond will divide his time between the Coordinated Science Laboratory, an interdisciplinary research group in the College of Engineering, and the Engineering Experiment Station, which has administrative responsibility for the College's total research program.

Martin said Desmond's new duties will involve all phases of Engineering Experiment Station administrative operations. One of his specific assignments, according to Martin, will be assisting in the development of plans for the future growth and development of research in the College of Engineering. "Basically," Martin said, "the addition of Mr. Desmond to our staff reflects the growth of engineering research at the University of Illinois. With our research expenditures passing the nine million dollar mark, we need additional administrative help to keep the program developing in an orderly manner. Mr. Desmond brings us the ability and experience that we need in this area of research administration."

Desmond first joined the University staff in 1951 as an assistant in the College of Commerce. He was an instructor in that college from 1952 through 1954. He first came to the College of Engineering in 1955 as business manager for CSL and became Assistant Director there in 1960. He holds degrees from the U of I in accountancy and in law and is a member of the Illinois Bar.

THE TEMPERATURE OF NOISE

People are often concerned with the volume of noise, the continuation of noise, and infrequently, the absence of noise. Two University of Illinois engineers are concerned with the temperature of noise.

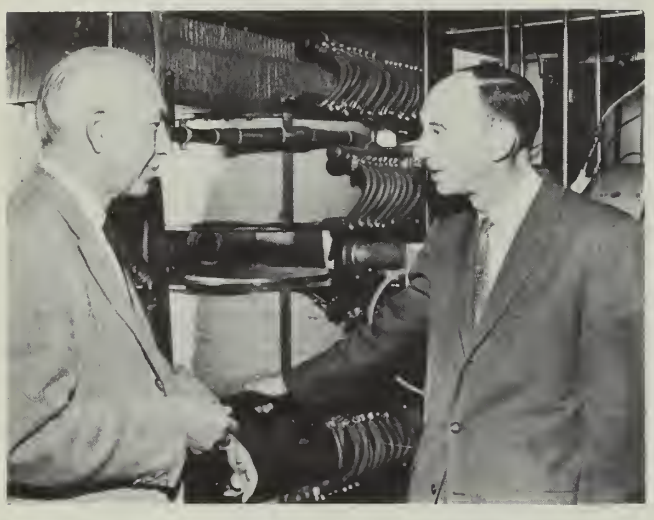
Edward P. Bialecke and K. N. Rao of the Department of Electrical Engineering's Gaseous Electronics Laboratory are presently working on temperature measurements in plasma afterglow. Their work is a part of an Air Force project that will eventually make use of rockets to study the ionosphere, the layer of ionized air high above the earth's surface which is so important to radio communication. In the meantime, however, research continues in earth-bound laboratory "ionospheres." The Bialecke-Rao "ionosphere," consisting of such gases as neon, helium, xenon, or nitrogen, is in a long cylindrical glass vacuum tube. The gas discharge tube is surrounded by a solenoid and uses microwave circuitry to control the electric currents involved in the experiments.

When proper conditions have been met in the experiments, a breakdown occurs in the gas creating a neutral region containing an equal number of ions and electrons called a plasma. It is important in the Bialecke-Rao experiments to measure the electron temperature of the plasma's "afterglow." This afterglow is similar to the effect seen on a home television screen when illumination lingers on momentarily after the power has been shut off. Because low electron temperature measurements are difficult to make directly, a microwave signal is introduced to heat the plasma's afterglow. The heated electrons then become more active — and more noisy.

The detected microwave noise is converted into visual images on the face of an oscilloscope, photographs are taken of the images, and the temperature is measured from the resulting pictures.

The laboratory data compiled by Bialecke and Rao are being incorporated with data from other EE researchers working on the Air Force-sponsored project (see *Engineering Outlook*, January, 1961). When the rocket is finally fired, it will signal the completion of an important phase of cooperative work by several U of I engineers and test the validity of the experiments which required the taking of a noise's temperature.

Dr. George K. Green (right), outstanding occelerotor physicist fram Braokhaven Nationol Loboratory, recently visited his alma mater, the University of Illinois. He is tolking to Prof. P. Gerald Kruger ond examining the mognet ond coils of o one-million-volt cyclotron they built in 1935-36 when Green was a groduote student in physics under Prof. Kruger. This pioneering cyclotron was ane of the world's first high-energy "atom-smashers." It is naw used as o device for onolyzing the beam from the University's twelve-million-valt cyclotron.



SUMMER PROGRAM FOR TECHNICAL INSTITUTE TEACHERS

Technical institute and junior college teachers in mathematics, electronics, and machine design will have an eight-week summer institute available to them at the University of Illinois next June 18 through August 11. The program is sponsored by the National Science Foundation, and financial assistance for all participants will be available in the form of stipends, dependent allowances, and travel allowances.

In addition to the *Engineering Mathematics Course, Mechanical Design Technology Course,* and *Electronics Engineering Problem Course,* there will be a series of seminars on the philosophy of technical institute education and the place of the technician on the engineering manpower team. Although there will be no tuition fees, there will be supplementary fees totaling $9.00 and room and board expenses. The University will reserve housing for single persons or families upon request. Further information, housing forms, and applications are available from:

Professor J. S. Dobrovolny
115 Transportation Building
University of Illinois
Urbana, Illinois

The deadline for applications is February 15, 1962.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 3, NO. 2, FEBRUARY 1962

INVESTIGATING IRREGULARITIES IN HIGH PLACES

A tiny radio transmitter designed and built at the University of Illinois is a vital element of the still orbiting satellite Discoverer 36. Built under the supervision of Professor George W. Swenson, Jr., of the Department of Electrical Engineering, the transmitter sends back to earth important information about irregularities in the ionosphere which play a major role in the success or failure of long-distance radio communications.

The Air Force satellite is circling the earth in a polar orbit 16 times daily and its transmissions are being received by the University's satellite tracking station near the U of I campus and in three other stations located from Michigan to Alaska. The signals are sent from a retractable steel-tape antenna that is unlike the U of I log spiral antennas painted on the Transit series satellites launched in 1960 (*Engineering Outlook,* June, 1960). The satellite's transmitter payload, code-named Nora-Alice II, acts "as a sort of beacon to enable us to study regions of the ionosphere by observing the way in which radio signals traversing it are changed," says Professor Swenson.

Agencies which cooperated on this project were the Lockheed Missiles and Space Company, the National Astronautics and Space Administration, and the Space Systems Division of the Air Force.

SANITARY ENGINEERING CONFERENCE PROCEEDINGS

Scientists and engineers are rapidly gaining new knowledge in the science of water and waste water treatment. This new knowledge can have value for our society only when it leaves the research laboratory and is made available to people working in the field. For this reason a series of Sanitary Engineering Conferences has been jointly organized by the Sanitary Engineering Division of the Illinois Department of Public Health and the Civil Engineering Department of the University of Illinois. The subject of the first conference was *Waterworks Safety;* the second was devoted to *Radiological Aspects of Public Water Supplies;* and the third was on *Disinfection and Chemical Oxidation in Water and Waste Treatment.*

The Proceedings of the last conference have just been published as Engineering Experiment Station Circular No. 71, *Disinfection and Chemical Oxidation in Water and Waste Treatment.* The 62-page Circular contains the program of the Third Sanitary Engineering Conference and the texts of papers given by E. J. Laubusch, R. D. Mann, C. W. Chambers, R. S. Ingols, R. E. Anderson, R. J. Brink, and M. E. Flentje. The articles are illustrated by figures and tables, and a large number of references for further reading are cited.

The subject matter is of interest to those who treat both surface and ground water, as well as to those associated with waste treatment. The use of chlorine, because it is used for so many purposes, is discussed at length in several of the articles. Other disinfectants and oxidizing agents for water and waste are discussed. Circular 71 is available from Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, for $2.00 per copy.

ENGINEERING ACTIVITIES CALENDAR

Requests to be included on the mailing list for the calendar of engineering seminars and discussions at the University of Illinois (*Engineering Outlook,* December, 1961) have come in from all over the United States. This suggests the increasing popularity of these public meetings and the possible need to restate that such a publication exists and is available. The weekly calendar lists topics, speakers, dates, times, and places of seminars, symposia, and other technical sessions open to visitors.

Copies of the calendar, which will be mailed free, are available upon request from the Engineering Publications Office, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois.

The student is studying geometry vio PLATO II, the secand generation U of I teaching machine which can teach mare than ane student at a time. PLATO (Pragrammed Logic for Autamatic Teaching Operatians), like a humon teacher, has the capability of giving the student information at different levels of complexity depending an the student's perfarmance. Automotian is a wanderful thing; now it's even possible to flunk by push button!

ENGINEERING OPEN HOUSE AT THE LAND-GRANT CENTENNIAL

"The first hundred years are the hardest" is an old joke about life. As the University of Illinois and the 67 other land-grant colleges approach the centennial of the Morrill Act, which made such colleges possible, the second century looms just as difficult, just as demanding, just as exciting and important as the first. This is especially true for the colleges of engineering.

In recognition of the centennial year of the Morrill Act, the theme of the Engineering Open House on March 16 and 17 at the University of Illinois will be "100 Years of Progress." Engineering College students will show visitors where engineering research and education now stand, and they will also give some intriguing glimpses into the future. Engineering Open House will have help this year in telling visitors about engineering. The first State Exposition of the Junior Engineering Technical Society will be held on the Urbana campus at the same time as Open House. JETS chapters from high schools all over Illinois will exhibit their projects and present their research papers during the Exposition. The best work will be sent on to the National Exposition of the JETS in the United Engineering Center in New York in May. Visitors to Open House this year will have this added bonus of seeing what Illinois' high school students are doing with their interests in engineering and applied science.

The fields of engineering range from buildings to bacteria, from supersonic aircraft to submillimeter electromagnetic waves. The variety of engineering subjects and tasks is almost infinite, and the engineering students will try to show their guests something in every major area. A nuclear reactor, electronic computers, and many other facilities will be open, and students and faculty will be on hand to explain. Registration will be at the Illini Union, where the JETS Exposition will also be held. Further information about schedules and accommodations is available from the College of Engineering, 106 Civil Engineering Hall, University of Illinois, Urbana.

UI MAN ON GOLDEN GATE BRIDGE STUDY

Peninsula-bound San Francisco is a city with its own special transportation problems. To keep the famous Bay from becoming a watery wall to progress rather than a golden gate to the west, two magnificent bridges have linked the city to Oakland and to Marin County. The more famous of the two, the Golden Gate Bridge, is still the longest suspension span in use.

Increasing traffic needs in the Bay area have resulted in a proposal for a rapid transit train system covering several counties, with one of the legs running from San Francisco across the lower level of Golden Gate Bridge. Consulting engineers working for the bridge directors have recommended against adding rapid transit tracks to the bridge, although Bay Area Rapid Transit District engineers had previously indicated the addition was feasible. A decision was then made to organize a board consisting of three outstanding structural engineers to consult on the problem and make final recommendations to the bridge directors. Dr. J. Stratton, the President of MIT, and Dr. Lee DuBridge, the President of the California Institute of Technology, nominated thirteen engineers throughout the United States from among whom the final selection was to be made.

The board chosen by the bridge directors consists of O. H. Ammann, New York City, member of the consulting engineering firm of Ammann and Whitney; Frank M. Masters, Harrisburg, Pennsylvania, member of the consulting engineering firm of Modjeski and Masters; and Dr. Nathan M. Newmark, Head of the University of Illinois Department of Civil Engineering.

Dr. Newmark is internationally known for his research and has been called upon many times for consultation in connection with unusual and complex engineering problems, generally involving structural dynamics. "This particular problem," Dr. Newmark said, "is not only unusual and complex, but, at the moment, a controversial issue, and I feel that it is a great honor to be selected to serve as a consultant on the board."

The three-man board held its first meeting in January in San Francisco.

A PROGRAM FOR OUTSTANDING HIGH SCHOOL STUDENTS

A recent study by the National Science Foundation states that by 1970 the United States will need 1,484,000 engineers, an increase of nearly 90 per cent over the 782,000 estimated by NSF in practice in 1959. The survey sets the need at least at 81,000 new engineers a year until 1970 to fill the demands of our growing economy, and yet the number of graduating engineers is dropping year by year (52,700 in 1950, 37,800 in 1960). The Engineering Manpower Commission of the Engineers Joint Council predicts an increasing shortage of engineers over the next few years.

There are a number of movements in progress to reverse this trend, such as the JETS Program (*Engineering Outlook,* September, 1961), a nonprofit organization to encourage and help high school students interested in engineering, and the NSF-sponsored Summer Science Training Programs for Secondary School Students. Last year 9,000 high school students took advantage of such programs at 190 institutions, including the University of Illinois. This summer the U of I will again conduct a six-week Summer Program from June 25 through August 3. Approximately 40 students who will be high school seniors in the fall of 1962, ordinarily those who are in the upper ten per cent of their classes, will be eligible for the programs. The deadline for applications is May 1, 1962.

Application forms may be obtained from Professor J. S. Dobrovolny, Director, 117 Transportation Building, University of Illinois, Urbana, Illinois. The Summer Program, like the JETS Program, will stimulate interest in engineering among outstanding high school students and give them a chance to see for themselves the many career opportunities in engineering.

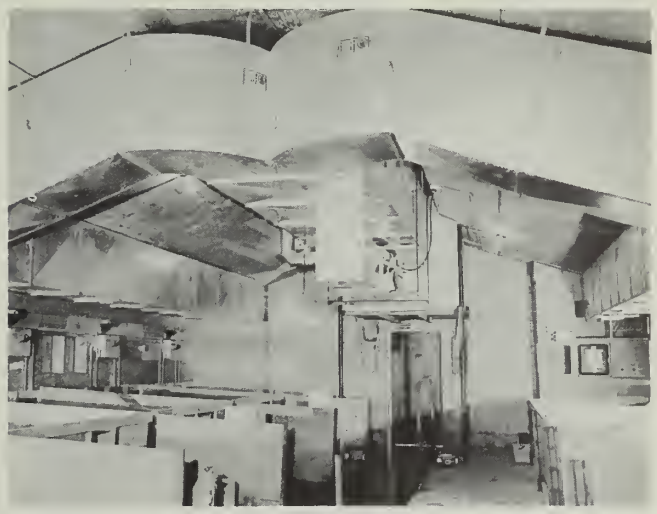
THE 3-2 PROGRAM

Engineering educators have long been concerned that their students learn not only engineering techniques, but also gain a broad understanding of themselves and of their civilization. Some of the students will someday head large corporations, direct powerful government agencies, and fill other positions that influence millions of lives. One way in which engineering students can seek a broader education is through a curriculum that is commonly referred to on the University of Illinois campus as the 3-2 program. This is a five-year program of study in which the student divides his time between liberal arts and sciences and engineering. Upon completion the student receives two bachelor's degrees, usually a B.S. and a B.A.

The entire program can be done at the University of Illinois or can be a combination between the U of I and some other liberal arts college. Schools in Illinois which cooperate with the U of I in this program are: Greenville College, Greenville; MacMurray College, Jacksonville; Rockford College, Rockford; Western Illinois College, Macomb; and Carthage College, Carthage. There are also two cooperating colleges outside of Illinois: Colorado College, Colorado Springs, Colorado, and Saint Joseph's College, Collegeville, Indiana.

"ENGINEERING" MORE MEAT FOR LESS MONEY

University of Illinois mechanical engineers have long done research to improve home environmental conditions with heating and air conditioning. Today U of I agricultural engineers are concerned with the control of livestock environments to promote disease-free growing conditions. Before the current study was begun at the University of Illinois, very little work of this sort had been done with swine. The picture shows an insulated, totally enclosed building built by U of I agricultural engineers to study environmental conditions surrounding the growth of swine from farrowing to finish. Wall controls provide automatic electric under-floor heat. The pressure ventilation system automatically varies the amount of air (completely fresh heated air is provided at all times) by a centrifugal fan delivering a maximum of 15,000 c.f.m. of air at two inches static pressure. Louvers on the inlet side of the fan automatically vary the amount of air directly with changes in humidity. Fan speed eventually will also be varied automatically when extreme changes in air are necessary. Automatic feeding, watering, and floor washing will be incorporated, with waste materials being drained into a lagoon. Data from this project, directed by Dr. E. F. Olver, may ultimately provide valuable information on environmental control for other types of animals.



Leoding a hog's life — with air conditioning

STATION DIRECTOR IN INDIA

India's efforts to train more teachers for her expanding engineering schools were examined in January by University of Illinois engineering research director Ross J. Martin. Professor Martin was particularly interested in the University of Illinois' cooperative program with the Indian Institute of Technology at Kharagpur, West Bengal, for engineering faculty development.

Since 1953 the College of Engineering of the University of Illinois has conducted a cooperative program in India with the support of the U.S. government Agency for International Development. Professor Martin made the official executive visit to inspect the University of Illinois program at Kharagpur. He also visited other institutions, including the Indian Institute of Technology at Madras, which is being assisted by West German engineering educators, and the Indian Institute of Science at Bangalore. His schedule included detailed discussions with the U.S. Technical Cooperation Mission in New Delhi and with Indian government officials.

Two programs for advancing engineering education in India are currently being operated by the University of Illinois under contract with the U.S. government. Since 1954 the University has played an important role in development of the Indian Institute of Technology at Kharagpur. Seven American engineers are there now for the University as part of the program. U of I assistance to India also includes having faculty members of various Indian engineering colleges come to the University of Illinois campus for graduate study in engineering and for instruction in undergraduate teaching methods, curriculum content, and college administration.

Recent Publications of the Engineering Experiment Station

Bulletin 458, *Theory of Non-Homogeneous Anisotropic Elastic Shells Subjected to Arbitrary Temperature Distribution,* by R. E. Miller, 36 pp., $1.00 per copy.

Bulletin 459, *On the Solution of Ill-Conditioned, Simultaneous, Linear, Algebraic Equations by Machine Computation,* by B. T. Chao, H. L. Li, and E. J. Scott, 16 pp., $1.00 per copy.

Bulletin 460, *Theoretical and Experimental Analyses of Members Made of Materials That Creep,* by O. M. Sidebottom, G. A. Costello, and S. Dharmarajan, 52 pp., $1.00 per copy.

Bulletin 461, *Effect of Heat Treatment and Chemistry on the Properties of Low Density Iron Base Sinterings,* by D. H. Boone and E. J. Eckel, 40 pp., $1.00 per copy.

Circular 71, *Disinfection and Chemical Oxidation in Water and Waste Treatment* (Proceedings, Third Sanitary Engineering Conference), 62 pp., $2.00 per copy.

Careers in Engineering, a guidance brochure for high school students, no charge for single copies.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 3, NO. 3, MARCH 1962

KEEPING THE TAIL FROM WAGGING THE AIRCRAFT

Sometimes a heavy windstorm will blow down big oak trees and leave little willows standing, showing one of the advantages of flexibility. Flexibility is the hallmark of the modern flight vehicle — airplane, missile, or spacecraft — and in such vehicles, as in willow trees, it has its advantages. It is also a source of problems for the aerospace engineer, and the staff of the U of I Aeronautical and Astronautical Engineering (AAE) Department have been actively engaged in solving these problems for more than a decade.

The wing tips of a B-52 can move up and down more than 30 feet before something breaks, which indicates how much flexibility is being built into modern aircraft. Flexibility results from keeping weight and drag as low as possible. While it is not simple to design flexible structural components, it is necessary: the aim of modern flight vehicle design is to build the lightest possible structure to do the required job at a reasonable cost. Without changing the vehicle's performance potential, every pound of structural weight saved means a ten-pound-lighter aircraft because there will be less fuel, less fuel tank, less rivets, etc. One of the research projects in AAE, sponsored by the Hughes Aircraft Company and directed by Dr. H. H. Hilton, has brought forth a method of using mathematical probability theory in designing to achieve minimum structural weight. This method has also made it possible to predict more accurately the performance of missiles.

As stated, flight vehicle flexibility is not all virtue and no vice. Sometimes, due to extreme lifting surface deformations, the flexibility of structural components can lead to flutter and changes in lift and control responses, which, in turn, can lead to failure. The tail or the wings can cause the plane to go out of control, or they may shear off. Such unpleasant phenomena are aggravated by creep (inelastic deformations with time), and thermal stresses (high temperature problems caused by high speeds or atmosphere re-entry maneuvers) which can cause failure to happen even faster. The theory of aeroinelasticity, which was developed at the U of I through another project supported by Hughes and directed by Dr. Hilton, offers solutions to this problem and is useful in predicting the useable lifetimes of aircraft.

This work, although fundamental in nature, has found many applications by the aerospace industry. The results have been published in many national and international journals and have provided ideas and incentive for M.S. and Ph.D. theses in the AAE Department.

STATE ISPE MEETING AT URBANA

The Central Illinois Section of the Illinois Society of Professional Engineers will be host for this year's 77th annual convention of ISPE. From April 12 through 14, 1962, some 500 delegates, members, and their families will assemble at the Illini Union and the Motel Urbana for a series of business meetings and social events.

Principal events will include the ISPE Executive Committee meeting and dinner on Wednesday, sessions of the House of Delegates on Thursday, group discussion by functional sections on Friday, with social events to round out the series of business and technical sessions. The Annual Banquet will be held in the ballroom of the Illini Union Building, followed by the final Ball in the Lincoln Room of the Urbana-Lincoln Motor Inn on Friday evening.

Presiding at business sessions will be H. F. Sommerschield of Chicago, ISPE president; Manuel Garcia, president-elect, will assume office at the luncheon on Thursday. Featured at that meeting will be an address by David Reyes-Guerra of the University, state director of the Junior Engineering Technical Society for the guidance of engineering-oriented high school students. Prof. Jerry S. Dobrovolny, Head of the Department of General Engineering, is chairman of the convention committee for ISPE, and Prof. Dan F. Hang of Electrical Engineering is 1962 president of the local Central Illinois Section.

This is the instrument far the United Drawing System invented by Professor W. L. Shick of the U af I Generol Engineering Department. The system allows direct projection between front, top, ond side views ond an isametric view. This model was built by on oircroft company for testing last summer. Earlier madels were reported in *Engineering Outloak*, July, 1960. The raised oluminum frame allaws the quadrangle to be in contact with the poper ot oll times. The photograph shows orthographic and pictorial views of a casting drawing and o finished port drowing on the same sheet.

TEACHING PROTECTIVE CONSTRUCTION METHODS TO TEACHERS

Providing shelter against nuclear attack presents problems that are in many ways entirely new to architects and engineers. A relatively small number of engineers have enough knowledge of the nature of these problems to provide reasonable solutions. This group includes some civil engineers at the University of Illinois, who have been studying structural response to nuclear detonations for the past 14 years. The Department of Defense has asked the U of I to make the knowledge gained from this long and extensive program available to architectural and engineering teachers from other institutions.

This summer the Civil Engineering Department will teach a six-week course on protective construction from July 16 through August 24. The course, directed by Professor J. D. Haltiwanger, will include a thorough study of the effects of nuclear detonations including air blast, ground shock, thermal radiation, and nuclear radiation, and the design of structures to protect human beings from these effects. Emphasis will be placed upon the theoretical bases of protective construction analysis and design problems. The purpose of the course is to prepare the teacher-attendees to teach similar courses in their own institutions.

Enrollment in the course will be limited to 50. All participants must be college graduates in civil or architectural engineering or in engineering mechanics, and must have a major in structural engineering. Applications, which were made to the Office of Civil Defense in Washington, are now closed. Three other schools are teaching similar courses: the University of California, the University of Colorado, and Worcester Polytechnic Institute.

The U of I Civil Engineering Department has worked in close harmony with the Department of Defense on the effects of nuclear weapons on structures since 1948. Dr. Nathan M. Newmark, Head of the Department and one of the world's outstanding authorities on structural dynamics, has directed the program over the years. Major contributions have been made in such areas as methods of analysis of the response of structures to dynamic loads, properties of materials under rapid strain rates, and the design and behavior of structural elements under dynamic loads. This research has included participation in nuclear weapons tests.

In the fall of 1961, again in cooperation with the Defense Department, the department gave seven short courses in which 236 practicing engineers and architects learned about fallout protection for the nationwide survey of existing public buildings ordered by President Kennedy. The major difference in the course to be taught this summer is that it covers not only fallout protection, but design to resist other effects of nuclear weapons as well.

According to Professor Haltiwanger, courses such as these will help to dispel some of the confusions about nuclear weapons effects and will demonstrate the ability of the engineer, using presently available materials and methods, to design structures to resist these effects. "When 'graduates' of our course and the other three schools' programs go out across the country to their respective institutions," he said, "they should be able to do a great deal in the next year or two to clear up many of the questions that have arisen about protective structures. They will have behind them the knowledge and experience of men who have worked and studied in this field for many years."

A REPORT ON THE GEESE WITH THE GOLDEN EGGS

The University of Illinois College of Engineering led the nation last year in number of first engineering degrees granted. In the 1960-61 academic year the U of I added 847 new engineering graduates to the nation's pool of engineers. During the same period the U of I was second nationally in the number of doctoral degrees awarded in engineering (79) and second in the number of undergraduate students (5,293) and doctoral candidates (420) in engineering.

These figures are included in a report of engineering enrollment and degrees in the 161 ECPD-accredited

institutions in the U.S. The report was prepared by Wayne E. Tolliver and Henry H. Armsby of the U.S. Office of Education and published in the February 15 issue of the *Journal of Engineering Education.*

Over the whole nation, the number of engineering students has dropped for the fourth consecutive year, 0.9 per cent below 1960. On the brighter side, the number of students seeking advanced degrees in the nation's engineering schools has continued to increase. A record 40,044 students were enrolled for advanced degrees in ECPD-accredited schools last year. The total of 7,856 enrolled for doctor's degrees is the largest on record.

The national decrease in total engineering enrollment presents a serious problem in the face of rising demand for engineers and scientists. It is even more significant because degree-accredited enrollment in all fields of study rose 19.4 per cent in the same period, according to Armsby and Tolliver. This means that engineering is getting a progressively smaller percentage of the total number of students in higher education.

SALARY ONLY A FRINGE BENEFIT

A survey of February, 1962, engineering graduates reveals that 20% went into graduate school, 18% went into the armed services, and 50% have been employed. Of those employed, the average starting salary was $560.00 a month; the highest was $670.00; the lowest was $444.00.

These figures would suggest that high pay is a major attraction for becoming an engineer. The graduates themselves don't think so: salary was listed as the fourth reason for accepting positions, after location, type of work, and opportunity. Nearly 30% of those already employed went into the aircraft and missile field, and over 18% went into the field of electronics. Engineering today is full of opportunity for exciting work and personal advancement in building tomorrow's world.

According to W. L. Everitt, Dean of the College of Engineering: "Each year there is an increasing demand for graduate engineers, making starting salary offers quite attractive. While this is a good thing in itself, it is not a good reason by itself for going into engineering. It is far more important, as these statistics show our graduates apparently realize, to be employed at a job that not only pays well, but offers opportunities to grow with the firm, to do the sort of work in which you are interested and which you will live for the rest of your life. A young man needs to think of his future; and there is an exciting future in engineering for people with talent, intelligence, and interest. The high salary is only a fringe benefit."

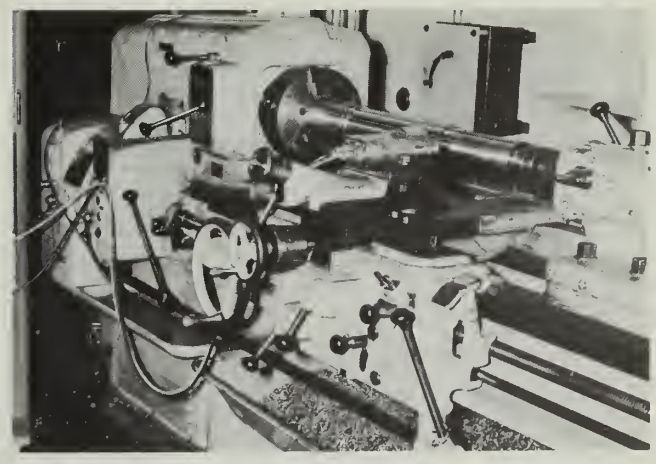
A TOOL FOR RESEARCH AND INDUSTRY

Engineering research often requires complex and specialized equipment. Much of this equipment is useful only in gaining new knowledge in the laboratory. It never finds its way into industry. Sometimes, as a useful "by-product" of research, a device will be developed that has value both in the laboratory and in industry.

One such device, a dynamometer used to measure cutting forces, was developed in the University's Metal Cutting Research Laboratory. While this instrument is used as a research aid in the lab to study forces that contribute to tool wear, it is equally useful for industrial metal cutting applications. This device, completely sealed to protect it from cutting fluids and excess humidity, can be adapted to most machine tool operations. It also has an overload feature to protect it from damage during extreme speed and depth-of-cut operations. It is even able to withstand the everyday use of undergraduate engineers in their course work.

Data obtained from the dynamometer permits analysis of cutting forces, cutting energy, effect of tool wear on cutting forces, machinibility, and influence of cutting fluids. This information aids in the designing of cutting tools and machines, as well as the planning of sequence operations. The dynamometer head is available, calibrated or noncalibrated, to measure forces in two dimensions. The force of a human breath can be detected by the research model, but the commercial model's lower sensitivity limit is about two pounds.

The Metal Cutting Research Laboratory is currently using the dynamometer in several research projects. (See *Engineering Outlook,* February, 1961, for a description of some of the projects.) The research program is directed by Professors K. J. Trigger and B. T. Chao of the Mechanical Engineering Department.



Dynamometer in use in the University's Metal Cutting Laboratory

NOISE CAN BREAK AN AIRCRAFT

A good tenor on a high note can break a drinking glass. Similar sound vibrations from jet engines can sometimes break structural components of the aircraft. Because such breaks are one type of fatigue failure, this phenomenon is referred to as acoustic fatigue. To members of the University of Illinois Aeronautical and Astronautical Engineering (AAE) Department, the name "acoustic fatigue" includes noise vibration failures and failures caused by the turbulent air (boundary layer) surrounding a flight vehicle piercing the atmosphere at high speeds.

Dr. Y. K. Lin, assistant professor of AAE, is engaged in several research projects on acoustic fatigue problems. Because such failures often occur in the thin metal skin of lifting surfaces or fuselages, Dr. Lin has concentrated on the theoretical requirements of thin-walled skin-stiffener components. The problem is how to proportion such components to resist acoustic fatigue without excessive weight. A noise environment cannot be precisely determined because it will vary from one take-off or launching to another, one velocity to another, or one flight path to another. Statistically, however, it conforms to some degree to certain patterns. For this reason Dr. Lin uses statistical techniques in his analyses.

Much of this important work has been sponsored by the Boeing Airplane Company; the remainder has been done on AAE Department funds. Many of Dr. Lin's contributions to the solution of acoustic fatigue problems have been adopted by industry in the design of airplanes, missiles, and spacecraft, and the results have been incorporated into the research program of the University of Southampton in England. The most recent publication by Dr. Lin on this general subject appeared in the January issue of the *Journal of the Aerospace Sciences.*

HOME HEATING UNITS

Oh Wind, if winter comes, can a heating bill be far behind? With apologies to Percy Shelley, this is a fair question for householders. The householder may not be able to be an expert in home heating, but with the help of the Small Homes Council – Building Research Council and the U of I College of Engineering, he can gain an understanding of how home heating systems work.

The SHC – BRC has recently revised its non-technical circular *Heating the Home.* The illustrated booklet discusses hot water and steam systems and current developments in forced circulation warm air heating and heating with electricity. Some of the advances in home heating can be credited to the Engineering Experiment Station, which has conducted cooperative research for many years with the National Warm Air Heating and Air Conditioning Association and the Institute of Boiler and Radiator Manufacturers.

The twelve-page circular is available for 15¢ per copy from the Small Homes Council – Building Research Council, Mumford House, University of Illinois, Urbana. A complete list of other current publications is available from the same address.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 3, NO. 4, APRIL 1962

SCIENCE AND ENGINEERING FOR HIGH SCHOOL STUDENTS

On March 16 and 17 the students of the U of I College of Engineering displayed their work and their laboratories to more than 20,000 visitors during the annual Engineering Open House. The event carried the theme "100 Years of Progress" in recognition of the signing of the Land-Grant College Act of 1862 by President Lincoln. Members of the Junior Engineering Technical Society (JETS) from Illinois high schools exhibited their displays at the same time in the Illini Union.

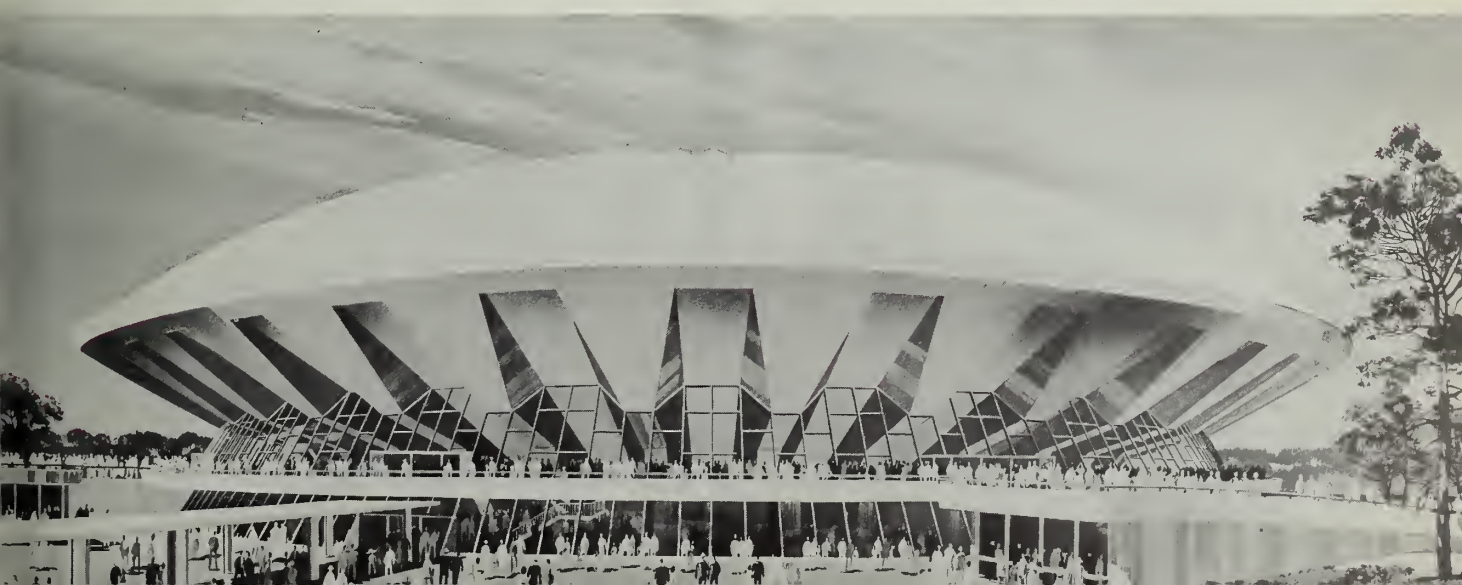
The cooperative efforts of University and high school students to make this event a success is indicative of the trend to give high school students more encouragement and guidance in science and engineering. For years the Junior Academy of Science has extended a helping hand to such people, and the establishment of JETS within the state this year has given a better means of helping engineering-oriented secondary school students.

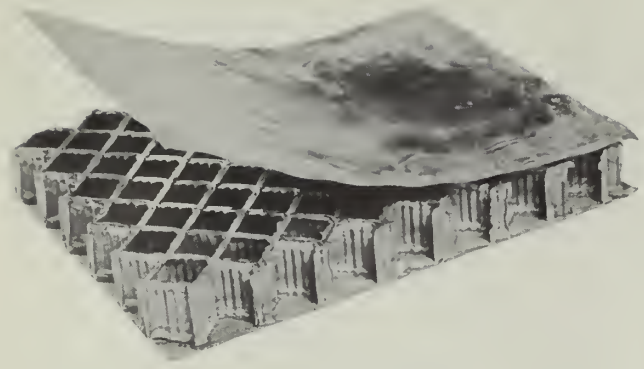
In 1963 the members of the Junior Academy of Science, JETS members, and students of the College of Engineering will all present displays for the public on the same weekend — May 10 and 11. A great deal of planning over the next year will be required for this combined science and engineering weekend, but one arrangement has already been made: the Junior Academy of Science students' exhibits will be located in the new U of I Assembly Hall. These will be the "top thousand" exhibits which have been given top honors at eleven district meets throughout the state of Illinois. The cooperation of the two societies and the U of I students promises a more exciting event than ever before.

LIME-POZZOLAN-AGGREGATE MIXTURES FOR HIGHWAYS

Engineering Experiment Station Circular No. 72, *A Correlation of Published Data on Lime-Pozzolan-Aggregate Mixtures for Highway Base Course Construction,* by G. W. Hollon and B. A. Marks, is now available for distribution. This circular is primarily a correlation of all available information pertaining to lime-fly ash-aggregate mixtures. It sets forth in summary form current thinking on the best ways of using this new paving material. A detailed bibliography is also included for those who wish to make a more comprehensive study of this subject. The price of the 55-page circular is one dollar per copy.

The U of I Assembly Hall will house the Junior Academy of Science displays in the 1963 science and engineering weekend.





Ceramic adhesive bonded honeycomb sandwich with top skin pulled back to reveal the interior structure.

CERAMICS: A LIST ITEM IN THE SPACE AGE

When a spacecraft re-enters the atmosphere, parts of it may reach temperatures in the thousands of degrees. Research engineers want to know how materials react to such temperatures, but obviously they cannot send up a spacecraft to test each one. Using a special microscope with which specimens can be examined and photographed while at temperatures up to 2000° F., members of the University of Illinois Department of Ceramic Engineering study the microscopic structure of ceramic bonding materials for use in spacecraft under actual flight-temperature conditions. They can also submit such specimens to tensile stresses while at elevated temperatures. Ceramic materials being studied now have exhibited shear strengths exceeding 3000 p.s.i. at 1200° F. and 800 p.s.i. at 1500° F.

These ceramic bonding materials are being developed to laminate metal structural panels of flight vehicles. Other, but related, ceramic bonding materials show promise of keeping dry-film lubricants from losing their efficiency at red heat. One of the problems in mixing dry-film lubricants and ceramic binders is matching the coefficients of thermal expansion of the two materials.

The problem in laminating panels with ceramic binders, on the other hand, is how to keep strength up to design limits at high temperatures without excessive weight. Panels of honeycomb structure are several times stronger than an equivalent weight of steel, but their high-temperature strength is dependent on the quality of the adhesives bonding the honeycomb and the facing plates together.

These Ceramic Engineering research projects, directed by Professor D. G. Bennett, are sponsored by the United States Air Force.

RESEARCH SUMMARIZED

From electrons to massive concrete structures, from deep underground to far out in space, researchers of the University of Illinois College of Engineering are probing the unknown. This is the picture presented by the College's annual *Summary of Engineering Research.* The latest edition, now available, presents an impressive variety of projects in a program that last year had budgets totaling more than nine million dollars.

The latest *Summary* tells the story of the 477 research projects in the College of Engineering at the beginning of the current fiscal year. The *Summary* reports that of the 477 studies currently being conducted, 367 are sponsored by agencies outside the University of Illinois. These outside sponsors include 47 federal and state agencies, 40 private companies, 19 industrial associations, and 4 private foundations.

A summary of each project and a list of publications resulting from the research during the period July 1, 1960, to June 30, 1961, are included in this 156-page volume. The descriptions list the objectives, study methods, achievements, and present status of each project. The names of the investigators are listed and the chief investigator is identified for each project.

This publication is available without charge from the Engineering Publications Office, 112 Civil Engineering Hall, Urbana, Illinois.

HERE'S *NOT* LOOKING AT YOU

James Thurber wrote a hilarious essay on his troubles with a microscope in college. Finally he saw something — to the despair of his instructor — the reflection of his own eye.

Thurber was ahead of his time; with an electron microscope, he would have had no problem. In fact, he would have had no lens to look into. This no stoop, no squint instrument, perhaps not the perfect solution for Thurber-like neophytes, has proven an extremely valuable tool for even the most sophisticated research scientists and engineers. At the University of Illinois, the Electron Microscope Laboratory is an important part of the research programs of many fields of engineering and the sciences.

This instrument, which has over a hundred times the resolving power of the optical microscope, makes magnification of up to 200,000 diameters possible. It can be defined simply as a microscope in which streams of electrons function in much the same way as rays of light do in an ordinary optical microscope. Since electron rays are not visible, there is no need of an eyepiece.

An electron microscope is made up of an electron gun (corresponding to a light source), electron lenses (magnetic fields which converge the rays on the specimen), and a projecting lens that forms the image of the specimen on a screen or on photographic plates.

The Electron Microscope Laboratory, an interdisciplinary facility of the U of I Graduate College, has six of these specialized instruments available for use by qualified faculty and graduate investigators. Established in 1942 by Professor G. L. Clark, it was the first electron microscope laboratory having commercial instruments located at a university in the United States. The Laboratory, presently directed by Doctor Rubin Borasky, is located in the basement of Bevier Hall on the Urbana campus.

The facilities and programs of the Electron Microscope Laboratory, although open to all University departments, are especially valuable assets to specialized areas of engineering research. In fact, there are a number of electron microscopes in the College of Engineering in areas that have a constant need for such instruments. In solid state physics, metallurgy, and ceramics, the electron microscope makes it possible to investigate matter that could not be detected by optical instruments.

HIGHER, FASTER, AND HOTTER

One of the greatest concerns of the modern aerospace engineer is heat and the many problems associated with it. A rocket or spaceplane faces it on atmosphere re-entry; a high-speed aircraft or missile faces it in the form of temperature build-up from air resistance; the aerospace engineer faces it on the ground, trying to anticipate where and why it may occur. Thermal stress problems are one of the many interests of the staff of the University of Illinois Aeronautical and Astronautical Engineering Department.

In addition to causing thermal stresses in flight vehicle structures, elevated temperatures can cause creep (inelastic deformations with time) or creep buckling (creep-induced structural failure). Any of these phenomena might cause failure, especially when they increase flight load deformations already present in wings or fuselages (*Engineering Outlook,* March, 1962). One of the AAE research projects, sponsored by the Air Force and directed by Dr. H. H. Hilton, has involved the analytical determination of thermal stresses in materials whose temperature dependent properties include creep. One of the most significant results of this work has been the formulation of the theory of nonhomogeneous viscoelasticity for thermal stresses. This theory, which is almost as hard to describe as it is to pronounce, permits the solution of complex viscoelastic thermal stress problems in terms of simpler elastic solutions. It offers savings in design time and money.

A flight vehicle structural column or plate that exhibits creep buckling from elevated temperatures often resembles a candle that has been in the sun too long. For several years the AAE Department has supported a program of research which has led to a better understanding of this phenomenon and a way of dealing with it through additional developments in the theory of viscoelasticity.

Various structural components of airplanes already flying have reached and withstood temperatures exceeding 1500° F. Spacecraft atmosphere re-entry temperatures exceeding 5000° F. have been recorded. It is clear that as flight vehicles go still higher and faster, they will encounter (and must be made to withstand) still higher temperatures. Such fundamental research projects as these will help pave the way.

ORDER FORM — send with remittance to Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois

☐ Bull. 461, *Effect of Heat Treatment and Chemistry on the Properties of Low Density Iron Base Sinterings,* D. H. Boone and E. J. Eckel. *One dollar.*

☐ Circular 71, *Disinfection and Chemical Oxidation in Water and Waste Treatment* (Proceedings, Third Sanitary Engineering Conference). *Two dollars.*

☐ Circular 72, *A Correlation of Published Data on Lime-Pozzolan-Aggregate Mixtures for Highway Base Course Construction,* G. W. Hollon and B. A. Marks. *One dollar.*

☐ *A Summary of Engineering Research: 1961. No charge.*

☐ *Engineering Calendar,* a weekly calendar of seminars and discussions at the University of Illinois. *No charge.*

POOR RICHARD, RAINDROPS, AND RESEARCH

Ever since Ben Franklin flew a kite in a storm, men have been interested in lightning as electricity. Franklin proved lightning is electricity, and more has been learned about it since. But many questions about the role of lightning in a storm are still unanswered.

Professor C. D. Hendricks, Jr., of the Department of Electrical Engineering and Mr. R. G. Semonin of the Illinois State Water Survey are seeking some of these answers. To help their quest, they have been given a nine-month U.S. Army Signal Corps grant for the study of cloud electricity as it affects rainfall formation. In addition to their studies of fundamental questions surrounding the origin of thunderstorm electricity, Professor Hendricks and Mr. Seminon will investigate the mechanisms of nature that bring millions of tiny cloud droplets together to form raindrops. All of these investigations for the joint University of Illinois-Water Survey project will take place inside a laboratory where artificial clouds will be produced and studied microscopically.

Although the techniques used in this new research effort will be far more sophisticated than those used by Franklin, perhaps practical-minded Poor Richard would be especially impressed with one advantage that he missed in his experiment — the researcher won't get wet!

PEOPLE AND PLACES

Professor James W. Westwater, international authority on the heat transfer characteristics of boiling, has been selected to head the Chemical Engineering Division at the University of Illinois. He will assume the position June 15 when **Professor Max S. Peters** leaves to become Dean of the College of Engineering at the University of Colorado.

Dr. John Bardeen, University of Illinois Professor of Electrical Engineering and of Physics who shared the Nobel Prize in Physics in 1956 as co-inventor of the transistor, was elected unanimously by the 86 chapters of Eta Kappa Nu to Eminent Membership in the Society. He shares the honor with four other people: one other Nobel laureate, two past presidents of the Institute of Radio Engineers, and President Kennedy's special assistant for science and technology.

Dr. Frederick Seitz, chairman of the Physics Department at the University of Illinois, has been selected to head the Presidential committee on the National Medal of Science. The medal is awarded to individuals who make outstanding contributions in the physical, biological, mathematical, and engineering sciences. On behalf of President Kennedy, the committee will consider recommendations for the award made by the National Academy of Science or other organizations.

Professors W. H. Munse and **A. S. Veletsos** of the University of Illinois Civil Engineering Department, and **S. D. Wilson,** visiting lecturer to the department, received three of the five national 1961 Research Prizes from the American Society of Civil Engineers. These prizes are awarded to Society members who make notable achievements in research related to civil engineering.

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ENGINEERING OUTLOOK
AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 3, NO. 5, MAY 1962

U OF I STUDENTS LEAD NATION IN NSF FELLOWSHIP PROGRAMS

University of Illinois students received more awards in two recent National Science Foundation fellowship programs than did students from any of the other 170 cooperating colleges and universities. The awards were for students in the various fields of engineering and science. The Foundation awarded 1200 Cooperative Graduate Fellowships for the 1962-63 academic year and 868 Summer Fellowships for Graduate Teaching Assistants for study and research in the summer of 1962. U of I students received 48 of the fellowship awards and 42 of the Summer Fellowships.

The colleges and universities cooperating in these programs originally evaluated applications for these prized awards. A second evaluation was made by 57 eminent scientist-scholars appointed by the National Academy of Sciences – National Research Council. Final selections were made by NSF solely on the basis of ability.

Upon receipt of the award announcement, Dr. W. L. Everitt, Dean of the U of I College of Engineering, said: "We are pleased by this recognition of our students by the National Science Foundation, and we take it as another indication that our efforts to attract high-ability students to engineering and science programs at the University of Illinois are succeeding." ◆

WHAT'S IN A WORD? A WORD LIKE 001011?

The University of Illinois Coordinated Science Laboratory has designed and built a computer that can't do arithmetic very well, at least not by comparison with many modern-day computers. Computers actually work with "words," words which are strings of zeroes and ones. Most computers treat these words as numbers and perform arithmetical functions such as addition and subtraction. If, however, the computer is designed to treat the words as symbols like the area code numbers in direct distance telephone dialing, it can control very complicated operations and behave in a fashion far removed from that of a desk calculator. This is what CSL's new computer, the CSX-1, does — it works more with the symbolic meanings of its words than their numerical values.

CSL has always been interested in the computer as a non-numerical decision-maker. Some of the CSL research projects involving such computer uses have included teaching machine research (*Engineering Outlook,* April 1961), game theory, defense systems (*Engineering Outlook,* September 1960), and real-time operations such as air traffic control. The recently acquired Control Data Corporation 1604 computer (*Engineering Outlook,* December 1961) is an excellent tool for such use because of its large memory capacity and its versatility, and the CSX-1, joined with it, will make an outstanding system for work on these problems.

The 1604 and the CSX-1 stand in the newly constructed Computer Room on the fourth floor of the Engineering Research Laboratory. They will soon be linked together by a communications system which will allow them to work as cooperating units. According to Professor R. M. Brown, head of the CSL Computer Group, this arrangement allows a wide range of versatility in problem solving. For example, some of the teaching machine programs for Illiac I (*Engineering Outlook,* March 1961) will be adapted to the new 1604-CSX-1 system, permitting a considerable expansion of the teaching capabilities and the number of students simultaneously under instruction. When the two computers are operating separately, the 1604 will be used for arithmetic calculations on other research projects, while the CSX-1 will be applied to non-numerical problems of less complexity than those associated with the teaching machine.

The CSX-1 represents some of the most advanced techniques of twentieth century computer technology, but the basic idea behind it is not new. Back in the seventeenth century Thomas Hobbes said, "Words are wise men's counters, — they do but reckon by them. . . ." ◆

University af Illinais Agricultural Engineers have been trying ta dry grain with small, single-phase electrical equipment aver langer-than-usual periads af time in arder ta reduce casts. The unit shawn cansists af a blawer, a sealed starage unit, and a heat pump. Saturated air leaving the grain passes aver the evaparatar cails which candense a partian af the water vapar in the air. This air is then heated and returned ta the grain starage, where it passes thraugh the grain, picking up maisture adiabatically. The cantralled atmasphere prevents the grain fram malding during the twa- ta three-manth drying periad. Althaugh a number af tests with this equipment have been completed, na final repart has yet been written.

THE NECESSARY FINAL STEP

Research has no value until it is communicated. The University of Illinois College of Engineering has communicated research results through its Bulletin series for more than 50 years. This has resulted in a worldwide net of communications with other researchers and with people in industry, but the system has not always allowed the quick dissemination of interim research results of immediate value to other engineers. A new series to give greater flexibility and shorter lead times will soon be started by the Engineering Publications Office. The series will be called Technical Reports.

The Technical Report series will present research results from the College of Engineering, just as the Bulletin series now does. The Bulletin series will be reserved for monographic treatments of final results from major research efforts. For example, some bulletins in the past have presented results, summaries, and evaluations of research programs extending over ten or more years. The Technical Report series, on the other hand, will carry material such as interim results of phases of larger research efforts, and other research results not of sufficient scope and length to justify bulletin treatment. By adding this new series the Engineering Publications Office will have a broader, better balanced program for publishing research results from all departments of the College of Engineering.

Editorial and review standards will remain the same as for bulletins, but printing will be done by offset printing methods. The advantages of this approach will be lower costs and shorter production times. In rapidly developing research fields, time can be extremely important in making research results available to other engineers.

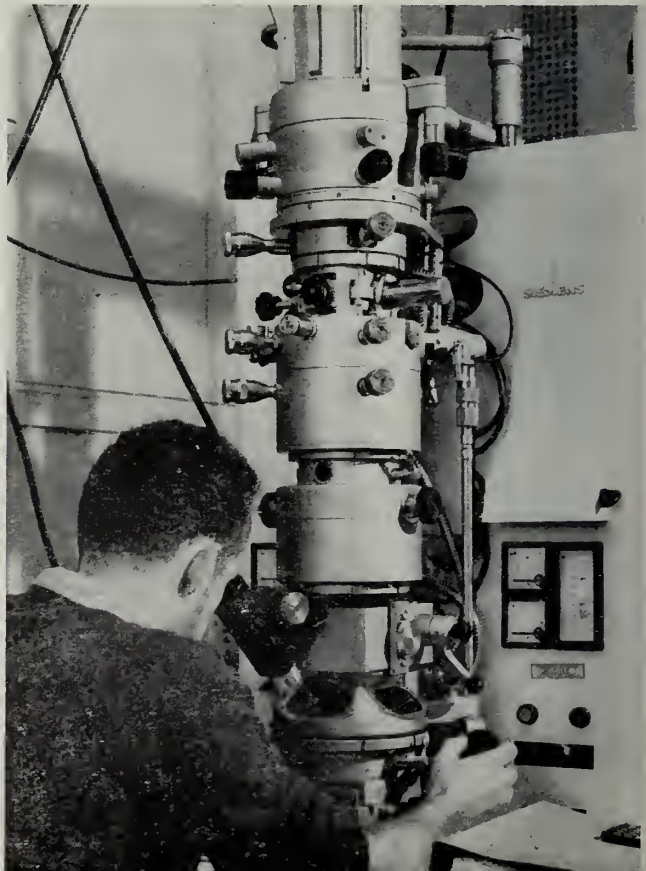
The first in this new series will be published late this spring, according to present plans. Publications in this series will be announced in *Engineering Outlook* as they become available. ◆

LIKE TO DEAL WITH THE ABSTRACT?

For the engineer who wishes to be well read but lacks the time, *Engineering Departmental Reports and Theses 1961* may be an answer. This publication, Engineering Experiment Station Circular 73, contains abstracts and bibliographic material for reports published departmentally in the University of Illinois College of Engineering during the period July 1, 1960, to June 1, 1961. Titles, authors, and advisors are presented for master's theses and doctoral dissertations.

Circular 73 is available free of charge from Engineering Publications, University of Illinois, Urbana. ◆

Whaever said a picture is warth a thausand wards may have been thinking af the electran micrascape. Several readers suggested that the article an these instruments in the April 1962 issue didn't give a clear picture af what an electran micrascape laaks like. Here is a clear picture . . .



U OF I RAILROAD RAIL RESEARCH

Although rail travel has always been one of the safest modes of transportation, American railroads have throughout the years sought ways of making it even safer. That safety has been made possible by a continuous program of research. A great deal of this research has been and continues to be done at the University of Illinois.

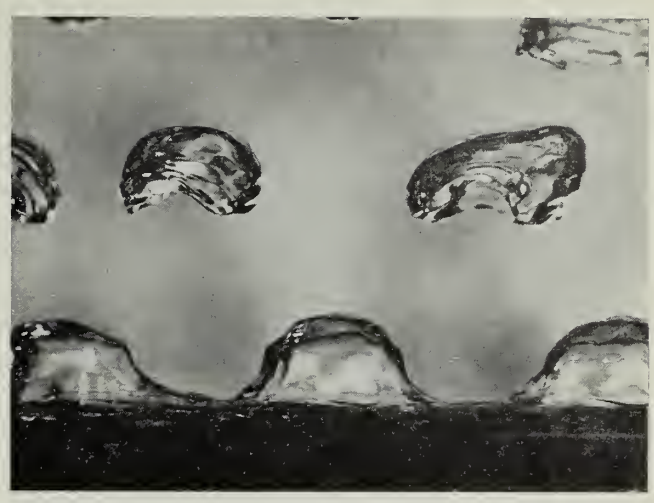
Although the University's early research on track and wheel problems brought important contributions to railroad efficiency and safety, one of railroading's most distressing problems continued to be the frequency of rail breakage. In 1931 rail breakage, which had been increasing for more than two decades, had reached 12,000 rails a year on American and Canadian railroads. U of I researchers found that the breaks were caused by microscopic "shatter cracks" which were hidden deep inside the rail head. They found that these shatter cracks resulted from too rapid cooling of the freshly made rails. From this finding the U of I engineers developed "controlled cooling" of the new rails. The importance of this research finding can be appreciated when one realizes that of the millions of miles of track that criss-cross the continent, not a single rail made by the controlled cooling method has since failed from a shatter crack.

Since the shatter crack problem has been solved, U of I researchers have turned their attention to other types of rail failures and are continuing to make progress toward safer and stronger rails. Some of the current research is reported in Reprint 63, "Progress Reports of Investigations of Railroad Rails," by Professor R. E. Cramer. It is available for fifty cents from Engineering Publications, University of Illinois, Urbana, Illinois. ◆

FOUNDRY INSTRUCTOR'S SEMINAR

The Fifth Annual Foundry Instructor's Seminar, sponsored by the American Foundrymen's Society, will take place on the University of Illinois campus June 21, 22, and 23. The meeting will be attended by approximately 150 high school, tech school, and college foundry teachers from all over the United States and from overseas. In addition to talks on teaching methods and foundry techniques, actual foundry work practices will be demonstrated in the U of I laboratories.

The seminar is open to foundry teachers who apply to Ralph E. Betterly, Education Director, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Illinois. Information about the seminar is available on campus from Professor James L. Leach in the U of I Foundry. ◆



A high-speed motion picture camera coupled to o microscope is o powerful tool for studying boiling ond other phenomeno in research on heat transfer. This photograph shows film boiling of isapropanol outside a ¼-inch-diometer steam-heated tube in one of the laboratories of the U of I Department of Chemicol Engineering.

SOME PEOPLE CALL IT RUST

Each year corrosion costs the public $6.5 billion a year. The University of Illinois Cathodic Protection Laboratory, under the Department of Mining, Metallurgy, and Petroleum Engineering, has facilities for the investigation of conditions under which corrosion occurs and its control by cathodic protection measures.

Corrosion is an electro-chemical process in which metal, going from the solid to the ionic state, loses electrons which produce a direct current (d-c). A solution to this expensive problem is cathodic protection: a method of supplying electrons to a corroding metal system for the purpose of reducing or eliminating the corrosion current. Such protection can be furnished in two ways: by the use of a rectifier furnishing an opposing d-c from an a-c source, or by the use of sacrificial (more easily ionized) anodes of magnesium, zinc, or aluminum. Either method can protect pipelines and cables indefinitely, while unprotected structures may fail within two years after construction.

One of the current interests of the Cathodic Protection Laboratory staff is the problem faced by companies that transport gas by pipeline over long distances. In areas where the pipelines parallel or run near high-tension power lines, they lie within the electric fields produced by the power lines — a circumstance that may prove to aggravate the ever-present natural effects of corrosion. Professor Walter H. Bruckner, technical director of the Laboratory, is presently studying the possibilities of giving such pipelines cathodic protection by using rectifiers to convert the a-c electric fields to the d-c that will resist

corrosion. If it works, the pipeline companies will get their cathodic protection without paying for the power involved! ◆

CULVERT DESIGN METHOD PUBLISHED

Engineering Experiment Station Bulletin 462, *Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basins,* by Ven Te Chow, is now available for distribution. It contains a scientific, practical, and simple method for determining the peak discharge of flow from small rural drainage basins for the design of waterway openings of culverts and small bridges. A design chart for climatic and physiographic conditions in Illinois is included.

The 104-page bulletin consists of a historical review of engineering studies and methods of waterway area determination, a survey of design practice in different state highway agencies in the United States, a collection and analysis of available hydrologic data for the state of Illinois, the development of a method for waterway area determination, a simplification of the developed method, a compilation of formulas for waterway area determination, and an annotated supplementary bibliography. Bulletin 462 is available for $1.50 from the Engineering Publications Office, University of Illinois, Urbana, Illinois. ◆

PEOPLE AND PLACES

Dr. H. M. Karara, University of Illinois Associate Professor of Civil Engineering, received the second prize of the Talbert Abrams Award for 1961 of the American Society of Photogrammetry. His prize-winning paper, "Maximum Bridging Distance in Spatial Aerotriangulation," was published in the September 1961 issue of *Photogrammetric Engineering.*

Professor Helmut H. Korst, international authority in the field of aerodynamics, has been named head of the University of Illinois Department of Mechanical and Industrial Engineering, and **Professor Seichi Konzo,** heating and air conditioning authority, was appointed associate head. The appointments are effective September 1, 1962. **Professor Norman A. Parker,** former head of the department, is now vice president, U of I Chicago Undergraduate Division.

Professor Frederick Seitz, authority in nuclear physics and physics of solids and head of the University of Illinois Physics Department, has been elected president of the National Academy of Science. His term of office will start July 1, 1962.

University of Illinois winners of four of the 1962 awards for scholarship, research, student activities, and achievement in the social sciences and humanities have just been announced: Lisle Rose Award — **Riaz Khadem,** senior in Civil Engineering from Champaign, Illinois; Hamilton Watch Award — **S. B. Sample,** senior in Electrical Engineering from Ferguson, Missouri; Honeywell Award — **C. H. Jones,** senior in Mechanical Engineering from Olympia Fields, Illinois; Harvey H. Jordan Award — **J. C. Wissmiller,** senior in Electrical Engineering from Cooksville, Illinois. ◆

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL 3, NO. 6, JUNE 1962

THE FIRST HUNDRED YEARS

The hundredth anniversary of the Morrill Act, the legislation that made land-grant colleges possible, is July 2, 1962. This Act allotted land from the public domain to establish and maintain colleges "to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." From this Act came a major impetus for the growth in the United States of public support of higher education at both land-grant colleges and state universities.

The 68 publicly supported land-grant colleges of the nation have been an important factor in the development of American higher education. These institutions number less than 4 per cent of the nation's colleges, but they enroll nearly 20 per cent of our undergraduate students and grant nearly 40 per cent of all doctoral degrees in the United States.

As we observe the hundredth anniversary of the Morrill Act, we can look back on the contributions of the University of Illinois College of Engineering and its Engineering Experiment Station as a part of a land-grant institution. From the founding of the College of Engineering at the University in 1870, engineers at the University have played a prominent role in the University's missions of education, research, and public service. The College of Engineering is currently second in the nation in number of undergraduate engineering students enrolled, first in the number of bachelor's degrees awarded in engineering, and second in numbers of master's degrees, doctor's degrees, and doctoral candidates in engineering. Also a recent national survey shows it to be second in the nation in amount of engineering college research. This consistently high standing in all areas of education and research is more notable since the number one school in each of these categories is not always the same. The University of Illinois has an outstanding but well-balanced program in all areas of engineering activity.

The list of individual accomplishments by the College of Engineering is impressive. For example, the first engineering experiment station in the United States was begun at the University of Illinois in 1903 and has grown to an annual research budget of more than nine million dollars. In 1887 Professor A. N. Talbot published the Talbot Formula, used as the standard means for finding the areas of waterways for bridges and culverts, an important feature of highway design. This remained the standard approach until superseded in 1961 by Professor V. T. Chow, also of the University of Illinois. With culvert costs running over one billion dollars per year in this country, this is a significant contribution. In 1913 Jacob Kunz of the College's Department of Physics made the first photoelectric cell. In 1922 Professor J. T. Tykociner of the Department of Electrical Engineering invented a method for putting sound on motion picture film. In 1926 Professor A. C. Willard designed the ventilating system for the Holland Tunnel, one of the outstanding engineering achievements of the '20's.

Skipping ahead, in 1940 the betatron, an important tool for nuclear physics, was invented at the University by Professor D. W. Kerst. In 1945 frequency independent antennas were invented at the University. These have found many uses, including the non-protruding antennas on such U.S. satellites as Transit I-B. These antennas are now widely used for radio communication and are considered a major breakthrough in antenna technology. In 1957 Professor John Bardeen, co-inventor of the transistor and co-winner of the Nobel Prize in Physics, published his theory of superconductivity, a phenomenon significant in many fields, including the search for ways to harness the energy of nuclear fusion.

Public service by the College of Engineering has taken many forms, including extension and short courses for industry, and service by outstanding faculty members on various advisory and consultative bodies for private industry and state and federal government agencies.

As we commemorate the hundredth anniversary of the Morrill Act making possible land-grant colleges and universities, the University of Illinois and its College of Engineering and the Engineering Experiment Station can claim a prominent part in the contributions of land-grant institutions to the growth of the nation. ◆

Agricultural engineers Jahn Siemens, *left,* and J. A. Weber demanstrate the new U af I tillage bin. The bin was built ta test farces on cultivator blades, miniature plow battoms and ather tillage toals as they move through the sail. Vertical and harizontal farces exerted an test taols by the soil are measured and recorded on graph paper in the machine on the right.

ULTRASONIC BOON TO MEDICINE

Six countries were represented at the Third Symposium on Ultrasound in Biology and Medicine at the University of Illinois Robert Allerton Park, June 4 through 8. Thirty-three speakers from England, Italy, Japan, Sweden, the United States, and West Germany discussed the application of ultrasound to a variety of biological problems. Of the 20 from the United States, 6 were members of the Biophysical Research Laboratory at the University of Illinois.

Some of the topics discussed at the Symposium were the uses of ultrasound to investigate and modify biological structures such as muscle, brain, and endocrine glands. Professor W. J. Fry, Head of the U of I Biophysical Research Laboratory, reviewed the research of the past several years on the application of ultrasound to the modification of the brain for relieving the symptoms of human neural disorders and discussed the future possibilities of ultrasound in medicine. A number of investigators gave papers on the use of ultrasound for viewing soft tissue, a technique in which a small fraction of the ultrasonic energy incident on some tissue interfaces is reflected and tissue structures not detectable by X rays can be seen. Movies illustrating the use of ultrasound for the diagnosis of various heart conditions were shown. Discussions were also held on the physical characteristics of sound fields, on acoustic absorption, and ultrasonically induced cavitation.

Elizabeth Kelly of the Biophysical Research Laboratory, who edited the proceedings of the previous symposium, was general chairman of the meeting. ◆

FACILITY FOR BASIC RESEARCH ON MATERIALS

Someday engineers will be able to decide what material they need for a job and have it made to order. This ability to make special materials for specific jobs is one of the goals of today's materials research. Such research at the University of Illinois will receive a big boost with the completion of the recently announced Materials Research Laboratory.

Funds for constructing and equipping the five-million dollar building will be provided by two federal agencies, the Advanced Research Projects Agency of the Department of Defense and the Atomic Energy Commission, and by the University of Illinois. The Laboratory will conduct interdisciplinary research in the materials sciences under the direction of a steering committee representing the five departments participating in the establishment of the Laboratory: Ceramic Engineering; Chemistry and Chemical Engineering; Electrical Engineering; Mining, Metallurgy, and Petroleum Engineering; and Physics. This steering committee is under the chairmanship of Dr. F. Seitz, Head of the University of Illinois Physics Department.

According to R. J. Martin, Director of the Engineering Experiment Station, the new Laboratory will approximately double the University's capability for research on basic properties of materials and its capacity to provide graduate education to scientists and engineers in this area of study. "It is certainly a recognition," he said, "of the University's past achievements in materials research, and it will help overcome the lack of laboratory space available for this work that we have encountered in the last several years. The five departments that will be involved have distinguished themselves in materials research, and this new facility will enable them to work together on problems in a way that is impossible at present." ◆

COAL TESTING REPORT AVAILABLE

Engineering Experiment Station Technical Report No. 1 is now available for distribution. *Progress in Coal Testing* by R. G. Wuerker, M. M. Singh, and N. Chakraverty outlines the Audibert-Arnu dilatometer test in the international classification of coal, the results of such tests on some Illinois coals, and the results of the determination of the Free Swelling Index of coals by means of an electrically heated furnace.

Technical Report No. 1 contains 42 pages, 8 tables, and 16 figures. It is available for one dollar per copy from the Engineering Publications Office, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois. ◆

SAFER DRIVING THROUGH MATHEMATICS

Perhaps you don't know how fast or slow you'll drive the next time you go on a trip — but we do, at least with a high probability. The speed motorists assume is an important question to the traffic engineer, and also a complex one; the answer depends not only on external factors such as traffic, road conditions, etc., but is further complicated by the behavior of the driver. Thus the theory of traffic flow depends on the application of knowledge from both the physical and the behavioral sciences. A recent study in the University of Illinois Department of Civil Engineering offers some answers.

This investigation, conducted by Dr. J. C. Oppenlander of the Traffic Engineering Section, involved the development of a mathematical method for predicting vehicle speeds on existing or proposed streets and highways. Forty-nine variables that represent travel conditions were measured in a series of observations of traffic on two-lane Illinois highways.

Factor analysis performed on a digital computer indicated that 68 per cent of speed variations are accounted for by five external factors: horizontal resistance (curves, no-passing zones, etc.); long-distance travel (driver residence, type of vehicle, etc.); marginal friction (roadside development, intersecting traffic, etc.); vertical resistance (grades, sight distance, etc.); and obsolete pavement (lane width, lack of pavement markings, etc.).

The results of this work permitted the determination of a more practical equation in terms of out-of-state cars, combination trucks, degree of curve, gradient, minimum sight distance, lane width, number of roadside establishments, and total traffic volume. This expression explained approximately 62 per cent of the variation in observed speeds.

While external factors account for a large percentage of speed variations, an additional 23 per cent may be attributed to the driving inconsistencies of the individual motorist. Coupling this data with the external factors offers a reasonably complete answer to why people select the speeds at which they drive. Such information helps the traffic engineer to evaluate the desirability of proposed highway improvements, to calculate the traffic conditions of planned highway facilities, and to establish reasonable speed regulations for different localities. The mathematical method has real value because it gives the traffic engineer a new tool to accomplish his purpose, which is to help man get from where he is to where he wants to be — comfortably, quickly, and safely. ◆

ORDER FORM — send with remittance to Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois

☐ Bull. 462, *Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basins,* Ven Te Chow. *One dollar and fifty cents.*

☐ Reprint 63, *Progress Reports of Investigations of Railroad Rails,* R. E. Cramer. *Fifty cents.*

☐ Tech. Report 1, *Progress in Coal Testing,* R. G. Wuerker, M. M. Singh, and N. Chakraverty. *One dollar.*

☐ Circular 73, *Engineering Departmental Reports and Theses 1961. No charge.*

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GENERAL RELATIVITY AND COSMOLOGY

First published in 1956 and now made available again, *General Relativity and Cosmology* by G. C. McVittie explores the possibilities of general relativity as a method in mathematical physics and astronomy and as a means of interpreting the data supplied by observation. It is intended as an introduction to the mathematical theory of general relativity and cosmology for graduate students and research workers. The author presents the theory in such a way that physical and astronomical applications are made as easy as possible.

Dr. McVittie is the Head of the University of Illinois Department of Astronomy. The book is available from the University of Illinois Press, Urbana, Illinois, for $6.95 per copy. ◆

PEOPLE AND PLACES

Professor B. C. Kuo, University of Illinois Department of Electrical Engineering, was selected as the 1962 FIER-Remington Rand Univac Field Scholar. The award will permit Dr. Kuo to spend a month this summer with the Industrial Control Computers Group at the Univac Division of Remington Rand in St. Paul, Minnesota.

Dr. N. M. Newmark, Head of the University of Illinois Civil Engineering Department, has joined with two other prominent bridge engineers in recommending that no rapid transit facilities be installed on the Golden Gate Bridge in San Francisco. The three-man study committee was selected last January (*Engineering Outlook,* February 1962).

Dr. J. E. Baerwald, Director of the University of Illinois Highway Traffic Safety Center, has been appointed by Governor Otto Kerner as a liaison member of the Governor's Official Traffic Safety Coordinating Committee.

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ENGINEERING CALENDAR AGAIN AVAILABLE

The Seminar and Discussion Calendar will again be available this fall for those interested in keeping abreast of the many technical sessions on the University of Illinois engineering campus. The weekly calendar lists topics, speakers, dates, times, and places of seminars, symposia, and other technical sessions open to visitors.

People not presently on the mailing list for the Calendar can receive it without cost upon request from the Engineering Publications Office, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois. ◆

STUDIES OF PRESTRESSED CONCRETE DESIGN CRITERIA

Analytical Studies of Relations Among Various Design Criteria, by Narbey Khachaturian, Iqbal Ali, and L. T. Thorpe, has been published as University of Illinois Engineering Experiment Station Bulletin No.463.

The properties of prestressed concrete present the designer with a complicated relationship among various seemingly independent design criteria. To simplify design and develop a thorough understanding of all criteria, the interrelationships must be studied. Khachaturian and his coworkers undertook to study analytically the design criteria for prestressed concrete beams. Their principal objectives may be grouped under two headings: 1. to study the criteria for service loads, to present relations among various unknowns and to develop a least weight design concept; and 2. to study the relationship between the allowable stresses at service loads and the safety factors against ultimate failure, and to present and discuss the effects of changing the allowable stresses on safety factors against ultimate failure. The study is limited to simply supported beams but includes both non-composite and composite construction.

Bulletin 463 is Part II of an *Investigation of Prestressed Concrete for Highway Bridges,* a part of the Illinois Cooperative Highway Research Program at the U of I. Part I, *Strength in Shear of Beams Without Web Reinforcement,* by M. A. Sozen, E. M. Zwoyer, and C. P. Siess, was published in 1959 as Engineering Experiment Station Bulletin No. 452. Bulletins 452 and 463 are each one dollar. They are available from Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana. ◆

A 278-DEGREE DAY

On June 16 the University of Illinois College of Engineering awarded bachelor's degrees to 278 students. On that date 271 of them were already employed, planning to continue studies for advanced degrees, going into the armed services, or returning to their homes in foreign countries.

Of the 157 already employed, starting salaries ranged from $525 to $750. Most of the remaining graduates were called into military service. Top average starting salaries were $616.64 for 14 graduates in aeronautical and astronautical engineering and $591.26 for 61 in electrical engineering. Good grades were worth $56 a month in starting pay; the six students who were employed from the top tenth of the class averaged $606.33 compared to $550.33 for the fifteen who were employed from the bottom tenth.

Of the 74 graduates who plan to continue studying for advanced degrees, 63 will stay in engineering, eight will major in business administration, and three will go into law. ◆

ONE MAN AND ONE PROJECT

How does one judge the accomplishments of a man?

While this seems to be the age of committees, design panels, and research teams, the successes of such groups are made possible only by the contributions of the individual members. Such successes are usually quite difficult to evaluate in terms of a single man, especially in organizations like the University of Illinois Engineering Experiment Station, which has many outstanding people. Nevertheless, this is the story of one man and one project.

In 1949 Dr. H. F. Johnstone of the U of I Chemical Engineering Division, who already had an established

The assembly of a precast concrete frame building of the type designed at the U af I progresses rapidly and smoothly. It is similor to the lumber rigid frame building described in the June 1961 *Outlaak*. This is a 30-faat-span building with frames spoced 16 feet apart. The T-section is used to receive concrete wall panels and to support roof members. Note haw frame legs are held in precast faatings with wedges until final grauting. Test results on such structures are in pracess of publicotion by the Engineering Experiment Statian. This bulletin will be onnounced in *Outlaak* when it is avoilable far distribution.

reputation in this field, was named chief investigator for a research study of aerosols sponsored by the Atomic Energy Commission. This developed into a long and successful relationship, lasting until Professor Johnstone's death last January. Seventeen technical reports on various findings of the study were published, a major contribution to the literature. New research techniques and devices also resulted from this research program, one example being the Multiple Klumb generator, a source of nearly uniform submicron-sized aerosol particles. Best of all, the program became a classic example of something that is always desired and encouraged at the University of Illinois, a close relationship between research and education. Over the years 63 graduate students received support from Dr. Johnstone's project and wrote theses on topics related to it.

The many and varied results of this one research project suggest another of the difficulties in evaluating a man's accomplishments, especially in light of the fact that this was only one job in Dr. Johnstone's 34 years at the University. ◆

CLASSROOM, LABORATORY, AND PLAYING FIELD

The story of the football player who didn't go to pep rallies because "those are for students" doesn't apply at the University of Illinois. The College of Engineering can supply some good examples.

Of the 254 students on varsity eligibility lists this year, 41, or 16.1 per cent, are enrolled in the College of Engineering. These 41 students last year had a grade point average that places them in the upper 40 per cent of the engineering classes. This grade point average also placed them considerably above the all-U of I average. Scholastically, the highest ranking athletes in several sports were engineers. The top scholastic record by an engineer last year was made by straight "A" student Dick Deller of the football squad.

Despite the mistaken belief that college athletes are more adept on the playing field than in the classroom, at the University of Illinois the student engineer-athlete has shown that these seemingly diverse fields can be compatible. ◆

QUANTITY WITH QUALITY

The United States has always been a leader in the techniques of mass production, an important factor in the country's economy and high standard of living. It has been said that mass production has been made feasible by two things: parts interchangeability and quality control. The University of Illinois has long played an important role in quality control, having helped to organize the Illinois Society for Quality Control in 1945, which became a charter section of the newly formed American Society for Quality Control (ASQC) in 1946.

The University has sponsored 15 quality control short courses since 1944. Since 1952 such courses have been taught every year. Professor J. A. Henry, who teaches equivalent courses in the industrial engineering curriculum has been the course coordinator since the start of the program. The Division of University Extension has made arrangements for each of the sessions, and the

courses have been taught by instructors from the U of I and from eight other Midwestern universities. According to Professor Henry, the courses have been attended by employees of 239 industrial companies from 304 separate plant locations. Enrollees have come from 36 different states, as well as from Canada, the Philippines, India, and Argentina.

Quality Control has become a distinct managerial function in recent years, providing information to and coordination between such diverse areas as research, product and process design, purchasing, inspection, and marketing. The ASQC, which started with 1,100 members 16 years ago, now has more than 14,000 members. Industry interest in quality control has increased continuously, which has contributed to the great popularity of the U of I quality control short courses. The next short course will start January 28, 1963, and last through February 7. Further information is available from Professor J. A. Henry, 130 Mechanical Engineering Building, University of Illinois, Urbana. ◆

SAFETY HELMET REPORT PUBLISHED

A report on safety helmet research conducted in the Mechanical Engineering Department of the University of Illinois is now available. This report describes in brief form the method and results of the tests conducted as well as the philosophy behind this research.

The publication, entitled *An Investigation of Construction Workers' Safety Helmets,* was written by Prof. C. E. Bowman, Prof. G. W. Harper, and L. D. Grider as a description of work conducted by L. D. Grider as one of the requirements for his master's degree in Mechanical Engineering.

This 15-page report is published through the Engineering Publications Office as Technical Report No. 2 and is available for one dollar. ◆

TECHNICAL REPORT SERIES GOES TO 3

The latest in the recently introduced technical report series is now available for distribution. Technical Report No. 3, "Elastic Buckling of Symmetrical Arches," is a report on research by N. C. Lind in the Department of Theoretical and Applied Mechanics.

This report includes the experimental procedures used to validate the theoretical development. Good agreement was found between the theoretical buckling load and the maximum load-carrying capacity of the arches. The collapse load was found to be considerably reduced by the presence of asymmetrical imperfections in the geometry or in the manner of loading.

The 33-page report is available for one dollar per copy from the Engineering Publications Office, 112 Civil Engineering Hall, University of Illinois, Urbana. ◆

CERENKOV RADIATION FOR ULTRAMICROWAVE RESEARCH

Coherent Cerenkov radiation, recently achieved at useful power levels for the first time in the laboratory of U of I researchers, is attracting international attention by those engaged in ultramicrowave research.

This radiation, named after a Russian scientist who discovered it in the early 1930's, occurs when a charged particle passes through a substance at a speed greater than the speed of light in that material. The achievement of coherence results from the bunching of an electron beam which causes the tiny electrons to act in unison instead of in a random fashion. This marks an important step toward closing the last unused gap in the spectrum of electromagnetic radiation which includes radio, X rays, light, heat, and similar phenomena (see *Outlook,* Nov. 1960).

The U of I Cerenkov studies, under the direction of Professor P. D. Coleman of the Department of Electrical Engineering's Ultramicrowave Laboratory, were reported by Professor Coleman at the 4th International Conference on Microwave Tubes held September 3–7 in Scheveningen, The Netherlands. ◆

THE FATE OF OUR GRADUATES

In five years since they left college, salaries of University of Illinois 1957 graduates in engineering have increased 62 per cent, according to a survey by the U of I College of Engineering's placement office. The 389 graduates who answered a questionnaire started at an average of $477 a month in 1957 and now average $771, reports Mrs. Pauline V. Chapman, college placement officer.

Advanced degrees are paying off for those who spent part of the five years getting more education. Members of the 1957 class who have only bachelor's degrees now average $757, with master's degrees $818, and with Ph.D. degrees $964.

More than half the graduates — 56 per cent — have stayed with their first employer for the full five years. Twenty-nine per cent have made one change, 11 per cent two, 4 per cent three, and only one individual as many as four.

Five years ago, beginning aeronautical engineers with bachelor's degrees averaged $505 a month, top for the class. Today these men average $812, but are topped by

the electrical engineers who started at $487 and now get $857, and by engineering physicists who started at $464 and now average $950.

Highest salaries today are received by engineering physicists with Ph.D. degrees — they average $1,167 a month. Electrical engineers with Ph.D. degrees get $1,034. None of the 1957 aeronautical engineers has as yet earned a Ph.D. although one is working on it.

Twelve members of the class now are in graduate college. Another 17 have become career military officers.

STARTING AND PRESENT SALARIES BY FIELDS ARE:

Field	Start 1957	Present salaries		
		B.S.	M.S.	Ph.D.
Aeronautics	$505	$812	$814	none
Agriculture	424	657	591	none
Ceramic	465	682	817	none
Civil	455	667	748	none
Electrical	487	843	898	$1,034
Engineering Physics	464	900	909	1,167
General Engineering	456	745	600	none
Industrial	459	715	805	870
Mechanical	473	733	771	none
Metallurgical	481	733	775	840
Mining	495	638	none	none

Mrs. Chapman noted that the average starting salary for engineering graduates, which was $477 in 1957, increased by more than 20 per cent for graduates in the class of 1962 and now is $577. ◆

PEOPLE AND PLACES

Dr. Ven Te Chow, Professor of Hydraulic Engineering, has been appointed to associate membership in the University of Illinois Center for Advanced Study for the coming year. For this appointment Dr. Chow will conduct research in the field of synthetic hydrology, which deals with the use of mathematical models for the design and operation of water-resource systems.

H. B. Puckett, USDA Research Agricultural Engineer stationed at the University of Illinois, was presented with a special USDA Merit Award and $300 in cash for meritorious service in the development of electrical controls for farmstead mechanization during 1959, 1960, and 1961.

The 1962 A. Epstein Memorial Award was presented to Professors A. R. Robinson, E. Chesson, Jr., and R. E. Olson of the University of Illinois Department of Civil Engineering.

J. T. Tykociner, U of I Professor of Electrical Engineering who invented sound-on-film motion pictures forty years ago, has come out of retirement at age 84 to teach the first course in Zetetics, the science of research. Zetetics was originated by Prof. Tykociner as a system for studying various aspects of research activity as it affects the growth of human culture (March 1960 *Engineering Outlook*).

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PRESTRESSED CONCRETE BEAM STUDY

Strength and Behavior in Flexure of Prestressed Concrete Beams, by J. Warwaruk, M. A. Sozen, and C. P. Siess, has been published as University of Illinois Engineering Experiment Station Bulletin 464. It summarizes the information on flexural strengths and deformation characteristics of prestressed concrete beams acquired in the course of an extensive research program carried out during the period 1951 through 1959. The bulletin, which is Part III of an *Investigation of Prestressed Reinforced Concrete for Highway Bridges,* is available for two dollars from Engineering Publications, University of Illinois, Urbana, Illinois.

Part I of the Investigation, *Strength in Shear of Beams Without Web Reinforcement,* Bull. 452, and Part II, *Analytical Studies of Relations Among Various Design Criteria,* Bull. 463, are both still available for one dollar per copy. ◆

A SOURCE OF ENGINEERING MANPOWER

According to informed estimates, the United States should have three times more engineering technicians than it now has for the most efficient use of engineering manpower. The University of Illinois has long been active in technician training program planning and coordination; in fact, for several years the College of Engineering has provided counsel in the development of two-year programs in engineering technology to the Superintendent of Public Instruction of the State of Illinois.

Illinois' first technical education conference-workshop, co-sponsored by the University of Illinois College of Engineering and the Division of Technical Education of the State of Illinois, was held on October 4 and 5 in Urbana. The speakers included Maurice W. Roney, U.S. Office of Education; W. J. Bartz, chief of Technical Education, Illinois Board of Vocational Education; and R. J. Martin, Director of the U of I Engineering Experiment Station. According to Professor J. S. Dobrovolny, Head of the Department of General Engineering and co-chairman of the conference, "Illinois is fourth in the nation in industrial production, but is so lacking in engineering technicians that many industries are forced to go outside the state to hire their personnel. This conference was devoted to alerting the people who administer technician programs to the curriculum needs, laboratory requirements, and subject matter necessary to train high-level technicians in mechanical technology. Some programs have already been started in Illinois, and this conference should give impetus to other areas to start their own programs." ◆

ENGINEERING CAREERS CONFERENCE

"Counseling High School Students on Engineering Careers" was the theme of this year's annual Engineering Alumni Committee meeting held October 26–27 on the University of Illinois campus.

The Engineering Alumni Committee, a group that now totals more than 150 U of I engineering graduates, was organized in 1952 to help high school students with the abilities and interests to better understand the opportunities, challenges, and rewards of an engineering career.

Among the speakers at the two-day session were David Reyes-Guerra, State Director of the JETS Program, and Miss Betty Lou Bailey, 1950 U of I engineering graduate from the General Electric Valley Forge Space Technology Center. A panel session on the image of engineering at the high school level included these panel members: D. W. Beggs, Principal, Lakeview High School, Decatur; T. A. Nelson, Counselor, Lyons Township High School, La Grange; and E. Stormer, Counselor, Mahomet-Seymour High School, Mahomet.

In addition to the engineering discussion, the committee members were conducted on a tour of the College's new Biophysics Research Laboratory, which is under the direction of Professor W. Fry of the U of I Department of Electrical Engineering. ◆

When is a house not a home? When it's a laboratory such as this split-level house, which will be the scene of a new research project in electrical home heating at the University of Illinois. Eight miles of wire were built into the structure to permit immediate determination of temperatures in 472 locations in and about the house and its heating system. The tower in back of the building supports equipment for recording weather data such as wind direction and velocity, temperature, and hours of sunshine. Prior to this project the house was used for warm-air heating and air-conditioning research. Boris W. Hryekewicz will be directly in charge of the new project, working under Prof. Rudard A. Jones, director, Small Homes Council – Building Research Council, and Prof. Warren S. Harris, who heads all heating research in the Department of Mechanical and Industrial Engineering.

MOTION PICTURES FOR ENGINEERS

Motion pictures may soon help the budding electrical engineer to a better understanding of complex technical theories. At a recent National Conference held on the University of Illinois campus on the use of instructional films for electrical engineering, suggestions were made for the introduction of models, cartoons, and other visual devices to aid students in visualizing abstract theories and concepts. The conference also set up guide lines for the types of films to be made, production facilities to be used, and the distribution system for the finished products.

The two-day session was conducted September 24-25 at Allerton Park Conference Center by the U of I College of Engineering in cooperation with the American Institute of Electrical Engineers, the Institute of Radio Engineers, and the American Society for Engineering Education. The conference was financed by a $23,000 grant from the National Science Foundation and attended by more than fifty leaders in engineering education from across the nation. A committee was established to obtain financing, guide production, and promote the use of demonstration films on electromagnetic fields and other areas of electrical engineering. The committee consists of J. G. Brainerd, University of Pennsylvania, Chairman; J. D. Cowan, Jr., Ohio State University; W. L. Everitt, University of Illinois; W. H. Huggins, Johns Hopkins University; J. H. Mulligan, Jr., New York University; R. M. Saunders, University of California; and W. G. Shepherd, University of Minnesota. ◆

BIOLOGICAL COMPUTERS

Among the signs in the halls of the University of Illinois Electrical Engineering Research Laboratory is one with the cryptic legend, "Biological Computer." Beyond identifying one research group in the building, it indicates nothing of its meaning. In fact, it could have several meanings.

For example, a biological computer might be one specially designed for biological problems, just as we have business computers. Again, a biological computer could be one that, part or parcel, is made of biological materials, systems, or organisms. Thus human beings are certainly biological computers when they engage overtly in computation.

But neither notion fairly describes the interests of the Biological Computer Group. Its main activities center on a third notion, that of biological behavior as computation. Biological organisms and systems are seen as automata, as "black boxes" whose output can be construed, in the broadest mathematical sense, as functions of the inputs to the boxes and conditions within them. Thus behaviors are seen as embodiments of computation.

The Group is particularly interested in those behaviors — or computations — that may be classed under the vague terms of "intelligent," "adaptive," "purposeful," "cognitive," and "creative," or even "self-determined," "conscious," and "mindlike." Part of the effort of the group is toward definitions of these terms that permit their application to the behavior of machines, or, failing that, to show that the terms are fuzzy even when applied to the born rather than the built.

A greater part of their effort is spent in design and construction of machines that show "intelligent" behavior. Now two sorts of strategy may be used in this task. We can call them the "synthetic" and the "artificial," using these terms as they are used in chemistry. A manufactured substance that is so like its prototype that it can be distinguished only by the fact of manufacture is synthetic; if it can be distinguished by objective test, but has a useful similarity, then it is artificial.

In the synthetic strategy, the attempt is made to come as close as possible to biological intelligence, its actual matter and means. If one wants to build a "brain," he studies brains — not only *what* they do, but *how* they do it, and by what means. If one wants to build a speech recognizer, he attempts to unravel and duplicate much of the structure and function, as well as the overall behavior, of the human auditory system.

Under the artificial strategy, one tries for any physical embodiment of the desired behavior as objectively defined. A speech recognizer constructed under this strategy might bear little or no comparison with the mechanisms of human speech recognition.

The U of I Biological Computer Group employs a mixed strategy. It does not refuse to borrow design principles from biology. In fact, its original thesis was that biological systems do embody valuable design clues. But the Group remains highly selective in what it borrows. It may copy several features of auditory design for a speech recognizer without feeling obligated to copy others that may be intimately connected.

In this, the Group differs from the new technology of bionics. According to the rules laid down by its founders, bionics involves more than the mere reproduction of biological behavior. A device is bionic only if it depends obviously and essentially on a biological prototype for its design principles.

Bionics has been described as the art of plagiarizing nature. If this is so, then the work of the Biological Computer Group can be described as the art of counterfeiting nature. The bionicist intends to copy as much of nature as he can get by with; the Group copies as little as it needs to. Both have economic utility as an ultimate concern; only the strategies differ.

But not all of the work of the Group is directed toward matters of immediate utility; some problems of the future are anticipated. A good part of its research is directed toward the study of organization; of what it means, in terms of the logic of mechanism and the transmission and processing of information within complex systems, to *be* an organism — an organization that persists in its ends despite the buffetings of a chancy world. This concern with organization is at the heart of the science of cybernetics, and it is as fair to call the Group "Cybernetics" as to describe it by the useful ambiguity of "Biological Computer." ◆

THE MIRACLE CHAIN

The water faucet in your home is the last link in a technological chain that brings water from earth to hearth by a simple twist of the wrist. This miracle chain is a "water distribution system," which is made up of miles of pipe, plumbing stations, storage facilities, blow-off valves, fire hydrants, surge protection devices, and thousands of other necessary accessories. The purpose of a water distribution system is to provide adequate amounts of water to all users, for all purposes, at all times, at reasonable pressures, and at reasonable cost.

These important systems were discussed at the Fourth Sanitary Engineering Conference held earlier this year on the University of Illinois campus. Co-sponsored by the U of I Department of Civil Engineering and the Illinois Department of Public Health, this two-day Conference on Water Distribution Systems was attended by more than 165 sanitary engineers and waterworks operators.

The proceedings of this conference have just been published as Engineering Experiment Station Circular No. 75, *Water Distribution Systems.* The 84-page circular contains the program of the conference and the text of papers given by C. W. Reh, M. B. McPherson, H. H. Benjes, G. T. Watson, R. A. Wilford, A. H. Gent, J. M. Rogeven, G. H. Ruston, and A. R. Moore. The articles are illustrated by figures and tables, and a large number of references for further reading. Circular 75 is available from Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, for $2.00 per copy. ◆

PEOPLE AND PLACES

Prof. H. F. Johnstone, well-known University of Illinois chemical engineer who died early in January, was honored at a three-day Memorial Symposium during the American Chemical Society's 142nd national meeting in September in Atlantic City, N.J.

Prof. John Bardeen, University of Illinois physicist who in 1956 received the Nobel prize as co-inventor of the transistor, received the 3rd Fritz London Award for distinguished research in low-temperature physics, at the 8th International Conference on Low Temperature Physics, meeting at the University of London in September.

Six University of Illinois College of Engineering professors were in Japan in September taking part in conferences on solid state physics held in Tokyo and Kyoto: **R. M. Thomson** and **C. A. Wert,** metallurgists, and **J. A. Koehler, D. Lazarus, C. P. Slichter,** and **R. O. Simmons,** physicists.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 3, NO. 9, NOVEMBER 1962

SANITARY ENGINEERING CONFERENCES

In January, 1959, the First Sanitary Engineering Conference was held on the University of Illinois campus. It was devoted to Waterworks Safety. Each succeeding year has brought another such conference to the campus, each of them sponsored by the Illinois State Department of Public Health and the University of Illinois. The 1960 Conference was on Radiological Aspects of Water Supplies, the next was on Disinfection and Chemical Oxidation in Water and Waste Treatment, and the last one was on Water Distribution Systems. Proceedings of each of the last three were published, respectively, as Engineering Experiment Station Circulars 69, 71, and 75, and are each available for $2.00 per copy.

Next January 29 and 30 the Fifth Sanitary Engineering Conference, devoted to Quality Aspects of Water Distribution Systems, will be held on the U of I campus. Among the topics to be discussed are those associated with contaminators, chlorine residuals, and circulation problems. As in past years, speakers and guests from all over the country are expected to attend.

Further information about the conference is available from B. B. Ewing, Professor of Sanitary Engineering, 212 Civil Engineering Hall, University of Illinois, Urbana. ◆

TAKING A LOOK AT THE RECORDS

The automobile, like a human being, has both a "birth certificate" and a "death certificate." There are various sorts of records in central locations on all automobiles in this country: statements of origin, titles, yearly registrations, etc. What do these records include? Whom are they for? Are they sufficient for their supposed purposes? The University of Illinois Traffic Safety Center has been asked to attempt to answer such questions as these by the Highway Research Board, National Academy of Science–National Research Council, Washington, D.C. Expected increases in population and motor vehicle registration, as well as the present lack of uniformity in registration and titling procedures in various states, indicate the need for more economical and efficient records in the future. This study, directed by A. K. Stonecipher of the U of I Civil Engineering Department, will be dedicated to an appraisal of existing practices, to deciding whether additional information should be obtained, and, if so, to planning how it can most reliably and economically be collected. The project may open new areas for information which could be of great value to law enforcement agencies, highway and city planners, traffic engineers, and administrators and lawmakers. ◆

MAYBE THEY'LL EVEN CHANGE THE RIVER'S NAME

Thousands of acres of southern Illinois land which have been periodically flooded in the past will soon be flood-free. The land lies in the Big Muddy River Basin, and the cure for the problem, the Rend Lake Dam and Reservoir, will be constructed on the river near Benton, Illinois. University of Illinois Hydraulic Engineering students and staff members have been studying many phases of the project for the last several years.

The University of Illinois studies on the Rend Lake Project started in 1957. U of I hydraulic engineering classes, working with the Illinois Division of Waterways and the Rend Lake Conservation District, constructed models of proposed spillways as part of their regular classroom work. This procedure, which provided the students with an opportunity to work on a real project under active development, has made a major contribution to the initial planning of the spillway section and various modifications which have been proposed for the structure. The project has now reached the stage of study and analysis by appropriate state agencies, consulting engineers, and other people concerned with reservoir development in Illinois.

This model of the outlet gates and hydraulic jump area of the proposed temparary water supply reservair near Waltanville, Illinois, was one of the results of the Rend Lake Project studies in the U of I Hydraulic Engineering Labaratory.

The University of Illinois work on the project, directed by John C. Guillou, Professor of Hydraulic Engineering, also involved studies of bottomland reclamation of areas which will be free of flooding after the dam is completed, and of the most economical methods of reclaiming the land which has previously been flooded. This work, according to Professor Guillou, has been an example of the sort of project which provides valuable experience for the students and, at the same time, a real service for the people of the state. ◆

FINDING THE RIGHT DIRECTION

If you saw a series of 65-foot telephone poles set in a 995-foot circle you might think the line crew had lost their sense of direction. However, if you understood antenna design and were familiar with the University of Illinois Radio Direction Finding Group, you would easily recognize that the seemingly misdirected series of poles were actually a Wullenweber antenna array.

This circular series of poles interlaced with 960 reflecting wires is one of the largest Wullenwebers in the world. Ingenious switching and circuit arrangements are located at the receiver in the center of the circle. The U of I unit, which has been in operation for three years, picks up remote radio signals reflected from the earth's ionosphere. The unit is designed to operate in the 4- to 16-mc. frequency range and is used in conjunction with research facilities in Columbus, Ohio; Washington, D.C.; and Canada. Previous research with the Wullenweber has involved studies of the accuracy of the device, possibilities for automatic operation, direction of arrival of signals reflected by the ionosphere, and signals reflected from the aurora borealis. The unit has noted such unusual effects as radio signals from Washington, D.C., arriving from the north instead of the east. Such odd behavior reveals information about the ionosphere just as reflected light may reveal information about an irregular mirror.

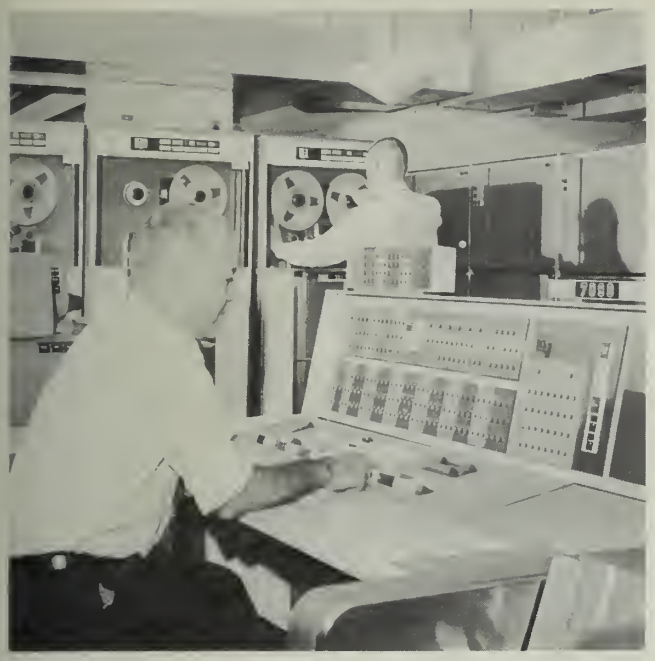
In November the giant Wullenweber will be teamed with a new electronic digital computer for enlarged research in radio direction finding techniques. When the Wullenweber-computer unit is in operation the radio signals received at the U of I site a few miles west of the Champaign-Urbana campus will be automatically recorded for analysis by the computer.

The direction finding project is financed by the U.S. Office of Naval Research and the Navy's Bureau of Ships. It is being carried out in the U of I Department of Electrical Engineering under Professors Albert D. Bailey, E. C. Hayden, and Robert S. Smith. ◆

WELDING SYMPOSIUM PROCEEDINGS PUBLISHED

University of Illinois Engineering Experiment Station Circular 74, *Proceedings of the Special Symposium on the Behavior of Welded Structures,* is now available for distribution. Following a reproduction of the welcoming remarks of Dr. N. M. Newmark, Head of the U of I Department of Civil Engineering, are eight papers given at the symposium by speakers from Belgium, England, France, Germany, and Sweden. Circular 74 is available for one dollar from Engineering Publications, University of Illinois, Urbana, Illinois. ◆

One of the featured speakers at the annual University of Illinois Engineering Alumni Committee meeting held October 26–27 on the Urbono campus was Miss Betty Lau Bailey, a 1950 U of I graduote in mechanicol engineering. Miss Bailey, presently warking with General Electric's Valley Farge Space Technology Center, spake on the rale of women in engineering tadoy.



The University of Illinois' 7090 computer in its new home of the Engineering Reseorch Loborotory Building.

ILLIAC RETIRES AFTER TEN LONG YEARS

One of the fastest growing fields in the world today is computer technology. Ten years ago Illiac, a computer designed and built at the University of Illinois, was put into service. It was not only one of the world's fastest computers, it was the only one at that time owned by a university. Next month it is being retired from service.

A new IBM 7090 computer, 20 times bigger in capacity than Illiac, is now available for use by U of I researchers. Unlike Illiac, which was sequential (computation stopped during input and output operations), the 7090 can be working on one problem while another is being put in and yet another is coming out. Input and output preparations are accomplished by a "slave" computer, an IBM 1401, which turns punched cards into magnetic tape and the magnetic tape into printing for the output — at the rate of 600 full lines per minute.

The new computer will allow much faster computation than has previously been possible at the University. A representative problem that would take fifteen years to solve by the use of nothing but pencil and paper, or 80 weeks with the aid of a desk calculator, can be solved by the 7090 in five seconds. It has 32,768 words in its main memory, which is backed up by magnetic tapes (two million words each) and a disc file (to be added later) which will hold nine million words.

This computer, as well as the new Illiac II (*Engineering Outlook,* March 1961), which is expected to be operational next spring, are facilities of the Digital Computer Laboratory, an interdisciplinary research facility under the U of I Graduate College. The Laboratory and its equipment are available for use by all departments on the campus. In addition to this service function, the Laboratory personnel engage actively in computer research, and there is a graduate training program associated with every research program. Illiac will continue to be used, to a limited extent, in some of the internal Laboratory research work.

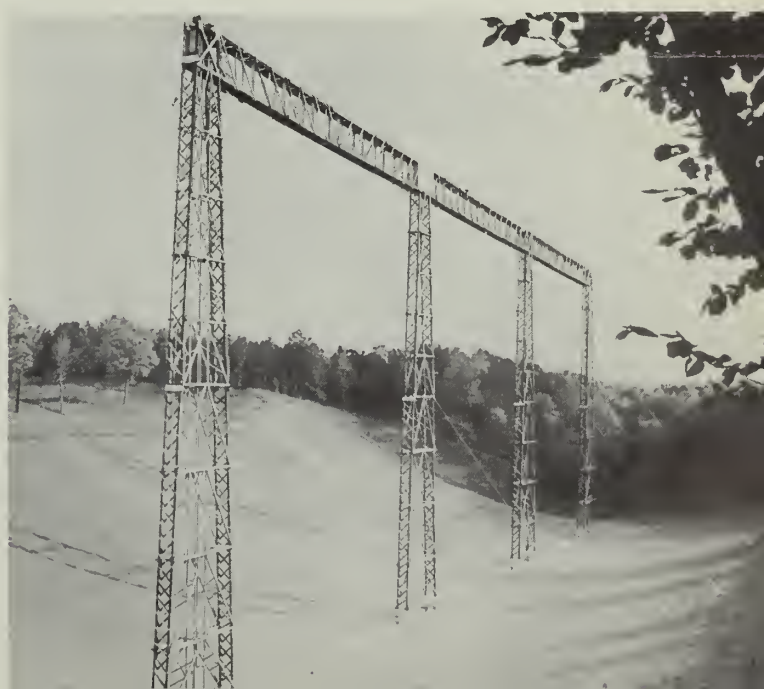
Illiac had a reasonably long life span for a computer. Although it was only operational for ten calendar years, it was in use substantially 24 hours a day — that's thirty years of work, which is usually considered sufficient for retirement in anybody's book. ◆

FALL ENROLLMENT FIGURES

Final registration figures for the fall term show the total University of Illinois student population on the main campus at Urbana to be 24,169. Approximately 3,650 are registered as engineering undergraduates and 1,200 as engineering graduate students.

Of a total of 4,597 students reported by the Chicago Undergraduate Division, 1,387 are enrolled in engineering. This makes a total of more than 6,200 engineering students registered at the U of I this semester. ◆

The University of Illinois Boord of Trustees ond other distinguished guests were present ot the November 9 dedicotion ceremonies for the giant U of I rodio telescope. Locoted in o reshoped rovine 5 miles southeost of Donville, Illinois, the telescope (see *Outlook,* Morch 1961) hos o porobolic reflector equol in oreo to five footboll fields put together. The rodio telescope mokes ovoiloble to reseorchers on instrument copoble of "heoring" sources of rodio emission from stors which ore invisible even to the most powerful opticol telescope.



PEOPLE AND PLACES

Prof. R. C. Fuson, a distinguished chemist who has been at the University of Illinois since 1932, has been honored by a $10,000 gift from nearly 400 former students and associates to be used as he may suggest for the benefit of chemists and chemistry at the U of I.

Dr. N. M. Newmark, Head of the University of Illinois Department of Civil Engineering, received the Theodore von Karman Medal of the American Society of Civil Engineers in October "in recognition of distinguished achievement in engineering mechanics and especially in structural dynamics."

Dr. R. B. Peck, Professor of Civil Engineering at the University of Illinois, was installed in October as a member of the Board of Direction of the American Society of Civil Engineers for a term of three years. He is now director for most of Illinois and part of eastern Iowa.

Prof. F. L. Spaulding, University of Illinois Department of General Engineering, was elected chairman of the Drafting Committee of the American Standards Association on November 26 in New York City. The previous chairman was **Prof. C. H. Springer,** also of the U of I General Engineering Department.

Charles H. Henry, graduate student in Physics at the University of Illinois, was awarded the Eastman Kodak Scientific Award of $1,000 in October. This prize is awarded "on the basis of outstanding contributions and progress either in graduate studies and research or in teaching."

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AT THE UNIVERSITY OF ILLINOIS

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 3, NO. 10, DECEMBER 1962

ENGINEERING AND LIBERAL ARTS

Yankton College, Yankton, South Dakota, has become affiliated with the University of Illinois College of Engineering in a combined engineering-liberal arts program. Students completing this program will receive a liberal arts degree from Yankton College and an engineering degree from the University of Illinois. Such programs of study can be taken entirely at the U of I, and there are other liberal arts colleges which cooperate with the U of I in combined programs. Other affiliated colleges outside of Illinois are Colorado College, Colorado Springs, Colorado, and Saint Joseph's College, Collegeville, Indiana. Cooperating schools in Illinois are Greenville College, Greenville; MacMurray College, Jacksonville; Rockford College, Rockford; Western Illinois College, Macomb; and Carthage College, Carthage. ◆

EVEN WHEN IT'S NOT PURE, IT FLOATS

Because the world's mineral resources are being used up so rapidly, today it is necessary to look for and try to obtain lower grade ores than would have been considered acceptable in the past. If mineral prices are to be kept reasonable, new methods of mineral beneficiation must be found or greater efficiency must be introduced into old methods. One of the widely used mineral processing methods in use today, flotation, is the subject of extensive research in the University of Illinois Mining, Metallurgy, and Petroleum Engineering Department by a group under the direction of Professor Norman Street.

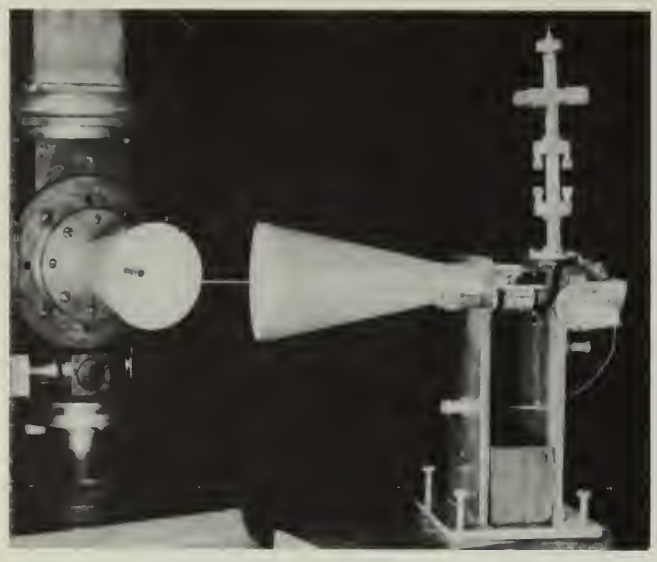
Flotation is a process by which minerals are floated to the top of a liquid surface where they can be collected. The addition of the proper kind and amount of chemicals to the water for the mineral being separated will make air bubbles stick to mineral particles and float to the surface, leaving the useless impurities behind. Today many millions of tons of ores are processed in this manner.

Although it is well known that the right chemical in the right quantity will make a given mineral stick to the bubble and rise to the surface, much remains to be learned about the electrical potential differences between the liquid surface and the mineral surface. This is one of the facets of flotation being studied by Professor Street's group. When a captive air bubble is brought up to a mineral surface under a microscope, it is possible to see that a thin film of liquid persists for some time between the bubble and the mineral. To increase the efficiency of the flotation process, the time interval before this film ruptures must be made as short as possible. These rupture times are a function of the surface potential developed at the mineral-solution interface, and Professor Street's group is studying methods of changing surface potentials in order to speed up the film ruptures.

The group is also studying the "contact angle" between the liquid and the mineral, i.e., the angle a drop of the solution will adopt to the mineral surface in air, which affects the ability of a bubble to stick to the surface of the mineral. There appears to be a relationship between surface potential and contact angle, and a relationship between surface potential and rupture time. Although quite a lot of fundamental work has already been done, much remains to be learned about such interfacial phenomena. These studies of hydromechanics, electroviscosity, and electrokinetics take on more and more importance as our iron ore, petroleum reserves, and other mineral resources become harder to find, harder to obtain, and harder to refine. ◆

EXCEEDING THE SPEED OF LIGHT

Cerenkov radiation occurs when a charged particle travels through a material medium at a speed greater than the speed of light in that medium (no, it doesn't prove Einstein wrong — read it again). Research done in the University of Illinois Ultramicrowave Laboratory has proven conclusively that powers in excess of one watt at millimeter wave lengths can be generated by means of Cerenkov radiation. This achievement represents an increase of a million times the power levels ever obtained by this means prior to the U of I work.



The Cerenkov rodiation emerges from the apporatus shown on the left. The detection equipment on the right, which is used to meosure both frequency ond power, would foce the rodiatian cone when in use.

Studies of Cerenkov radiation represent one approach to a most challenging technical problem: the production of electromagnetic radiation in the wave-length range between 0.1 millimeters (far infrared radiation) and 1 millimeter (microwaves). This submillimeter region is composed of ultramicrowaves, potentially useful in communications, radar, and as laboratory tools for investigating many physical phenomena.

The present frontier of useful wave lengths obtained with electron tubes still lies between two and three millimeters. Many people now feel that electron tubes are nearing their practical frequency limit and that an entirely new set of techniques will be required for further advances into the submillimeter region. Cerenkov radiation techniques offer some possibilities; quantum electronics techniques are also being brought to bear on the problem by the U of I Ultramicrowave Group. Of particular interest are those techniques which use light to energize atomic systems which, when they revert to their unexcited state, emit ultramicrowaves. Spectroscopic investigations are presently being made in order to identify and evaluate materials suitable for this application. Current Cerenkov radiation work includes the generation of such radiation in ferrites and in electrically neutral ionized gases (plasmas).

The Ultramicrowave Group will be well represented at the Millimeter and Submillimeter Conference in January at Orlando, Florida. Professor Paul D. Coleman, director of the U of I Group, will make the opening address, and five technical papers reporting recent accomplishments of members of the group will be presented to the international audience. Professor Coleman is on leave of absence from the University for the current academic year as a visiting professor at Stanford University. Until he returns, the U of I Ultramicrowave Group is under the direction of Dr. Murray D. Sirkis. ◆

ADVANCED DEGREES IN THE LAND-GRANT SCHOOLS

The University of Illinois is one of the top five land-grant institutions in the awarding of master's and doctor's degrees in all fields, according to a study of a ten-year period (1949–59) recently published by the U.S. Office of Education. At the master's level, Illinois, California, Wisconsin, Minnesota, and Ohio State conferred 33 per cent of the land-grant total. At the doctoral level, Illinois, California, Wisconsin, Ohio State, and Cornell awarded 49 per cent of all doctorates conferred by the land-grant institutions over the ten-year period.

Among all the 155 accredited land-grant schools, the University of Illinois College of Engineering is second only to the Massachusetts Institute of Technology in the number of doctoral candidates and doctor's degrees awarded each year in engineering. ◆

ASCE RESEARCH PRIZES TO UI PROFESSORS

Every year since 1955 the American Society of Civil Engineers has awarded prizes for notable achievements in research related to civil engineering. For the second year in a row two staff members of the University of Illinois Civil Engineering Department have won these research prizes. This year the award winners were Professors Ven T. Chow and William J. Hall. Last year awards went to Professors William H. Munse and Anestis S. Veletsos. Presentation of the awards to Chow and Hall will be made during the next meeting of the Society in February at Atlanta, Georgia.

Dr. Chow, Professor of Hydraulic Engineering, directs the U of I teaching and research programs in hydraulic engineering. He is one of nine faculty members recently appointed associate members of the University's Center for Advanced Study, established to encourage creative achievement and scholarship by providing recognition to scholars of the highest distinction. He was recommended for the Research Prize for "an outstanding contribution to the knowledge of flood protection and farm drainage." He is author of *Open-Channel Hydraulics,* a well-known book in that field, and *Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basins,* Engineering Experiment Station Bulletin No. 462. The latter, which contains a scientific method for determining the peak discharge of flow from small rural drainage basins, is available for $1.50 from Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois.

Dr. Hall, Professor of Civil Engineering and director of a number of research projects in brittle fracture mechanics at the University of Illinois, is cited for "outstanding contribution to the knowledge in the field of initiation, propagation and arrest of brittle fracture." Brittle fracture of steel structures has been a problem for many years but has received major attention following World War II because of the number of steel ships that failed. Brittle fracture failure, characterized by a lack of ductility and energy absorption, usually occurs without warning and is often catastrophic. The object of brittle fracture research is to find out why and when steel may become subject to brittle fracture and to provide the designer with methods of avoiding such conditions. Major research work, much of which has been carried out at the U of I, has contributed to design practice. Recent research carried out by Dr. Hall and his colleagues includes studies of fracture propagation in wide steel plates, studies of fracture initiation as affected by different welding procedures, and application of research findings to design.

Both men have also received the A. Epstein Memorial Award for faculty achievement, Chow in 1955 and Hall in 1958. ◆

SUMMER ORIENTATION FOR NEW STUDENTS AND PARENTS

Last summer the University of Illinois held a series of 39 summer orientation meetings for new students, their parents, and relatives. According to E. E. Stafford, Associate Dean of Students, a total of 4,350 people attended, more than double the number who came in 1961, the first year of the program.

The visitors met with representatives of the faculty, housing division, and administrative offices. Presiding at each session were County Chairmen of either the University of Illinois Dads or Mothers Associations. Anyone interested in attending one of these programs next summer may write to E. E. Stafford, Associate Dean of Students, 319 Student Services Building, University of Illinois, Urbana, Illinois. ◆

FRICTION: A TOOL FOR WELDING

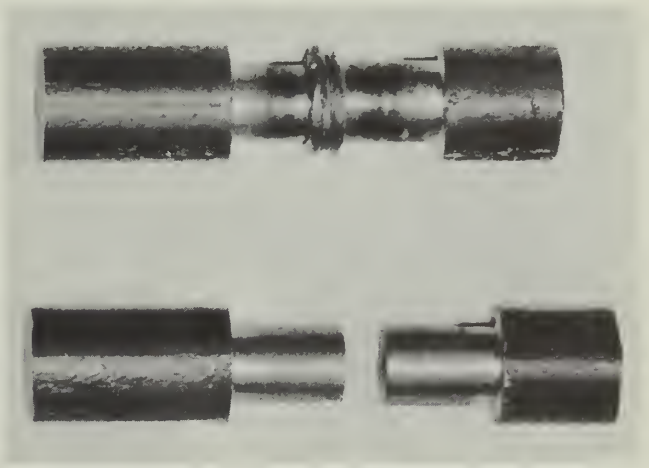
Friction is a paradox. While even an engineer couldn't live without it, many of his efforts are spent in trying to overcome it. At the University of Illinois, however, friction is being exploited. In the Department of Mechanical and Industrial Engineering the heat generated by friction between two metal specimens is being used to weld the specimens in a bond as strong as any other weld currently in use.

While the phenomenon of friction is not yet completely understood from a scientific standpoint, the process of friction welding has been used on metals in Russia and on plastics in the United States for several years. Because of the lack of research, however, its application has been severely limited.

Friction welding studies at the University of Illinois are being conducted by Mr. M. B. Singer in the Mechanical Engineering Welding Laboratory. Tests have been conducted primarily on low-carbon steels, although a few other materials have been tested. The weld, produced by rotating one specimen while pressing another specimen against it, occurs in four stages: wear in, preheat, constant heat, and upset. The whole process takes less than four seconds for a ½-inch-diameter specimen, and can be achieved using a modified lathe. Less power is consumed by this system than by arc or resistance welding, and no special equipment is needed to weld many dissimilar metals. Further, there is no contamination from the heat source, and studies of welding environments are feasible.

One of the current questions being considered in this project concerns the welding of malleable iron, which loses its malleability when subjected to high temperatures for long periods of time. Because of the short welding time the problem of brittleness in malleable iron welds may be overcome by this technique.

The basic properties of materials are also being investigated for this process. For instance, the transition temperature of the base material is being established and subsequent tests on transition temperatures in the weld area will be conducted. Once the principles behind this welding process are more fully understood, the area of application may broaden considerably. In addition, knowledge will be gained of the phenomena of friction, the generation of heat by friction, and the deformation of materials. ◆



Two similar specimens before and after welding by friction. After welding, the upset material can be machined off if necessary.

AN ENGINEER'S NIGHT BEFORE CHRISTMAS
or
A BIT OF ADVICE FOR SPACE AGE DESIGNERS

Twas the night before Christmas, and all thru the plant,
Not a creature was working but me and Van Zant.
The specs were all written and ready to go,
In hopes that the drawings would soon be, also.
A batch had been finished, and already checked
But others were not, as you might well expect.
So we, both as zealous as Scrooge's poor clerk,
Had just settled ourselves for a long evening's work —
When out on the lawn there arose such a clatter,
We sprang from our desks to see what was the matter.
The security lights on the new-fallen snow
Gave the luster of blastoff to objects below.
When, what to our wondering eyes should appear,
But a miniature space capsule and eight tiny (but extremely powerful) hydrazine-propellant boosters tandem mounted in series so the pilot could steer;
And a little round astronaut, so lively and quick,
I thought for a moment he might be Saint Nick.
But then Van Zant asked me, "Did you hear him yell
All those names to his boosters as his capsule fell?
'Now Atlas! now Saturn, now Vanguard and Gemini!
Let's make our next landing beside that old chiminey!
On Nike! on Redstone! on Titan and Polaris!
It's only tonight that Canaveral can spare us!' "
As we drew in our heads and were turning around,
Down the chimney the astronaut came with a bound.
He was dressed in a spacesuit from his head to his foot,
And his clothes were all tarnished with ashes and soot;
"This soot," he said, smiling, "is not from your chimney,
It's caused by the heat of atmospheric re-entry!"
A wink of his eye and a twist of his head
Soon put us at ease, although he then said:

"Tell me, are your schedules really so tight,
Or do you get overtime for working tonight?"
I looked at Van Zant; then he looked at me;
I said, "It's a matter of deadline, you see . . ."
"We've got a tough problem," Van Zant said with a groan,
"In hanging the micronite up in the T-zone."
The astronaut chuckled, "Well, that's why I'm here,
In packaging, I was the first engineer."
He spoke nothing more, but went straight to the work,
And studied the problem; then turned with a jerk,
He smilingly told us to take a good look,
And held out a Christmas tree ornament hook.
Even though we both knew he had found the solution,
By then we felt ripe for a state institution.
"Well, fellows," he said, "All your systems are go;
It looks A-OK, so I've now got to blow."
And laying a finger astride of his nose,
And giving a grin, up the chimney he rose.
He sprang to his capsule and into the door,
And then blasted off with a Titanesque roar.
"Happy Christmas," he yelled, as he flew out of sight,
"Keep your stuff simple and it's bound to be right!"

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SECOND CLASS
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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 4, NO. 1, JANUARY 1963

HIGHWAY AND TRAFFIC ENGINEERING CONFERENCES

The 49th Annual Illinois Highway Engineering Conference will be held at the University of Illinois on March 5, 6, and 7. The 15th Annual Traffic Engineering Conference will be held on March 7 and 8. Professor Ellis Danner, 300 Civil Engineering Hall, is the Highway Conference Director, and Professor John Baerwald, 404 Civil Engineering Hall, is the Traffic Conference Director.

Advance registrations are available for either of these conferences through Professor R. K. Newton, Division of University Extension, 116d Illini Hall. A registration fee of $2.00 per person is charged, which entitles attendance at either or both conferences. This fee, which should not be mailed with advance registrations, is payable at the conference sign-in desks. All interested persons are invited to correspond with the conference directors for further information or conference programs. ◆

SUMMER PROGRAM FOR TECHNICAL INSTITUTE TEACHERS

For the third year in a row technical institute and junior college teachers of mathematics, electronics, and machine design will have an eight-week summer institute available to them at the University of Illinois. The program, which will take place June 17 through August 10, is sponsored by the National Science Foundation. Financial assistance for all participants will be available in the form of stipends, dependent allowances, and travel allowances.

In addition to the Engineering Mathematics Course, Machine Design Technology Course, and Electronics Engineering Problems Course, there will be a series of seminars on the philosophy of technical institute education and the place of the technician on the engineering manpower team. The University will reserve housing for single persons or families upon request. Further information, housing forms, and applications are available from Professor J. S. Dobrovolny, 115 Transportation Building, University of Illinois, Urbana, Illinois. The deadline for applications is February 15, 1963. ◆

REMOVING ELECTRONIC SNOW

Many ways have been used to rid our streets and highways of troublesome winter snows. Another kind of snow — electronic — is equally troublesome to the fringe area television viewer. New antennas developed at the University of Illinois which show promise of solving this problem will soon reach the counters of the nation's retail radio and TV stores.

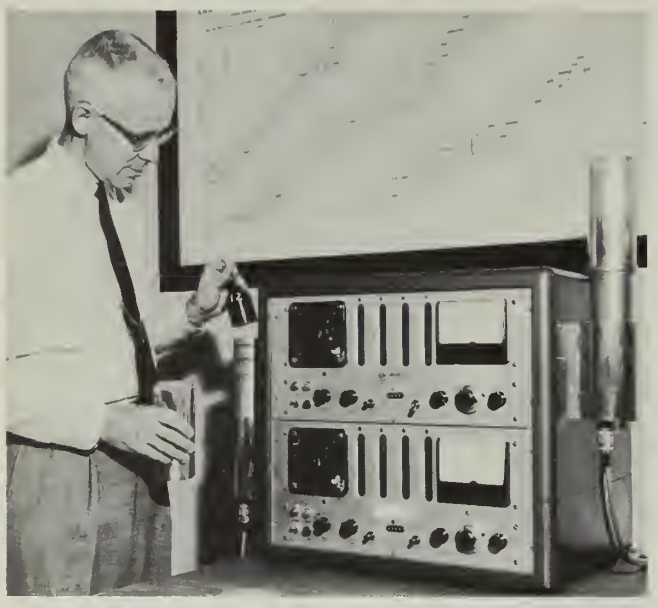
Log-periodic antennas, developed by Paul Mayes, Professor of Electrical Engineering, and Robert Carrell, E.E. graduate student, have the ability to receive all TV channels with equal clarity. This is possible because the antennas are designed in such a way that they do not depend upon the frequency of the channel being received.

The U of I Foundation, which holds the patent rights to the antennas, recently issued a license to a New York manufacturing firm to produce and market VHF and UHF antennas that use the U of I log-periodic principle. Full-scale production started last month and six different VHF models are currently being put on the market. The licensee also is developing similar antennas for the UHF range, plus a combination UHF-VHF model.

Although the new antennas should prove especially valuable to fringe area viewers, the unique features inherent in their design will help TV owners in all areas to avoid the agonizing choice between clear reception of one channel or poor snowy reception of several. ◆

U OF I Ph.D. PROGRAM FASTEST GROWING IN UNITED STATES

The University of Illinois shows the greatest growth in doctorate degrees in engineering of any institution in the nation, according to data for a ten-year period collected by Dr. Ralph Morgen, President, Engineers' Council for Professional Development. In 1950–51, the University granted 39 doctorates in engineering, and by 1960–61 the number had grown to 79. The University of Illinois ranks second in number of engineering doctorates to the Massachusetts Institute of Technology, which granted 97 engineering doctorates in 1960–61. ◆



Professar J. E. Pearsan af the General Engineering Department is placing a bottle of rodon gas an a photo-multiplier tube which counts the scintillatians as a measurement of the amaunt af gas the bottle contains. By means of a computer program, it is possible ta calculate back to the time when the sample was collected and determine the amaunt of rodan gas escaping fram the earth's sail. Professor Pearson is canducting these air pollution studies under a grant fram the U.S. Public Health Service.

BUT HOW WILL WE STOP SAYING TWO BY FOUR?

The 2 x 4 may soon become extinct. Everyone knows what a 2 x 4 is, and almost everyone knows it is really only 1⅝″ by 3⅝″. According to William A. Oliver, Professor of Civil Enginering at the University of Illinois and Chairman of the Board of Review of the American Lumber Standards Committee, some 2 x 4's are not even 1⅝ by 3⅝; if they are cut green they will shrink to even smaller sizes.

The relationship between moisture content and size has long been a topic of discussion in the lumber industry in this country. The Lumber Standards Committee, which is appointed by the Department of Commerce to establish and maintain standards of lumber size, pattern, quality, and inspection, has been concerned with the problem for years. Believing that there is now sufficient information available on this relationship to set a new standard, the Committee has named a subcommittee of nine to study the problem and make recommendations.

Professor Oliver, who was appointed to the subcommittee, says that the new standard will set the size dimension lumber will have to be when it reaches moisture equilibrium, and this size may well differ from the sizes currently in use. In addition, he says, a study is being made of lumber sizes from the standpoint of strength and stiffness which may also show up a possibility of using smaller sizes for a given job than are now used. "The new standard," he says, "which will be based on moisture content and strength requirements, may give us some new common lumber sizes — but if it does, they should offer the consumer a better product at a better price than the sizes we are now familiar with." ◆

U OF I TEAM WINS SCHOOL DESIGN PRIZE

An architect-engineer team from the University of Illinois, consisting of Brian J. Crumlish, John T. Hanley, and Carl R. Nelson, won first prize of $4,000 in a design competition conducted by the American Institute of Architects and sponsored by the Office of Civil Defense. The problem was to design a school to incorporate fallout shelter capability meeting the minimum requirements of the federal government, as well as fulfilling all the basic requirements of a school. A total of 99 designs were entered, and there were 26 award winners.

The central idea of the first prize solution was the use of sculptured earth forms to provide pleasing relief in an otherwise flat Midwestern community and to provide the required radiation protection. The concept provides for dual use of a large portion of the total floor area of the school, thus providing a familiar environment for the shelter occupants in a period of emergency. To put it in the designers' words, "Our design is intended to meet government fallout shelter requirements without looking like an oil tank from outside or in."

The school's classrooms, with their many-windowed outside walls, are placed around central facilities such as gymnasium-auditorium, food services, library, washrooms, offices, and other service units. The heavy interior walls of the classrooms baffle corridors that surround the central area. This central area is covered by a massive roof which extends far enough to screen "sky-shine" radiation. Doors from classrooms (and other entrances) into the central area are behind heavy baffles which provide complete radiation shielding of interior space.

When used as a shelter, the central area would allow normal activities by occupants, with corridors serving as dormitories. The area also contains supplies, ventilation equipment, an auxiliary power plant, and fuel for extended periods.

The winners were able to draw on their experience in regular activities at the U of I. Mr. Crumlish, a member of the staff of the UI Small Homes Council–Building Research Council, has been working on the design of homes with fallout protection built into regular living

areas and has worked on a number of designs for elementary schools in the Midwest. Mr. Hanley, a faculty member in the Civil Engineering Department, is an authority in fallout and blast protection and has participated in the training of other educators and engineers in methods of radiation analysis and protection. The third member of the team, Mr. Nelson, was formerly in the U of I Department of Architecture and is now at Notre Dame University. ◆

THE STATEWIDE CAMPUS

The job of a state university is to offer comprehensive educational programs to all the residents of the state. The University of Illinois is no exception; in fact, because not everyone can come to the University campus, the University goes to them. This is one of the activities of the U of I Division of University Extension.

Many engineering courses are offered through the Extension Division. All of these courses — graduate, undergraduate, or specially designed non-credit — are planned to provide continued professional development through new knowledge about the ever-changing and rapidly advancing modern fields of engineering. They provide the practicing engineer the opportunity to continue his education in his specific field of interest. Many members of the faculty of the U of I College of Engineering who teach advanced courses on the campus teach the same courses in various cities around the state. They are flown to and from their off-campus classes in University aircraft.

Such off-campus courses are offered year around over the whole state of Illinois. They meet one evening per week, usually for three hours. Engineers taking courses for graduate credit are registered in the Graduate College at Urbana and receive the same credit as on-campus students.

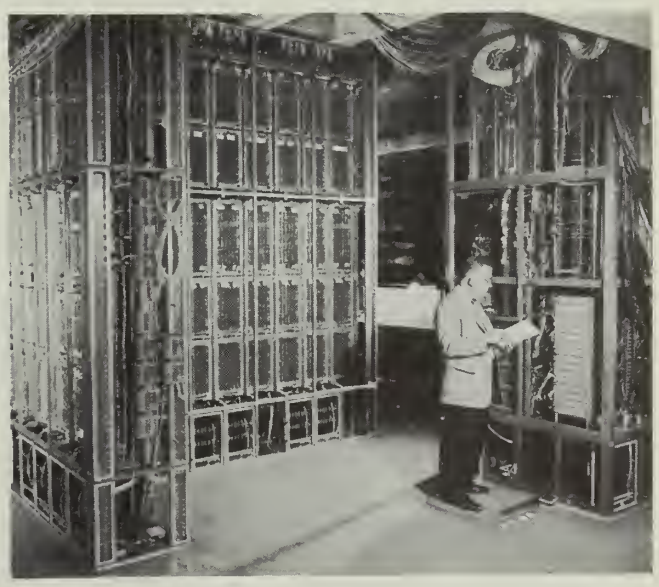
The Professional Engineer Refresher Course is one of many engineering courses taught in this program. Starting the first week of February, 1963, it will be taught in the following Illinois cities: Arlington Heights, Bloomington, Blue Island, Chicago, Des Plaines, East St. Louis, Elgin, Elmhurst, La Grange, Moline, Ottawa, Quincy, Rockford, and Springfield. For more details on these or other types of courses to be offered in 1963, write: Extramural Engineering Extension, 205 Arcade Building, University of Illinois, Urbana. ◆

TWO NEW COMPUTERS AT THE U OF I

Five years ago the staff of the University of Illinois Digital Computer Laboratory (D.C.L.) began work on a large, ultra-fast computer which would eventually replace Illiac. Illiac, which was also designed at the U of I and put into operation in 1952, was retired from service last December 31. A new IBM 7090 was placed in operation (*Outlook,* November 1962). Now the new Illinois computer, embodying advanced techniques in asynchronous circuits, methods of arithmetic, and machine organization, is nearing completion.

The new computer has a word length of 52 bits, an addition or subtraction time of 2.0 to 2.5 microseconds, multiplication time of 7.6 to 8.8 microseconds, and division time of 15 to 20 microseconds. Studies are being made to reduce these times further before the computer goes into actual operation. It has three memories: a fast transistor memory of 10 words, a core memory of 8,192 words, and a magnetic drum memory of 65,536 words. The organization of the machine includes a considerable amount of parallelism. It has three controls that operate simultaneously, which will allow three different phases of a problem to be worked on at the same time, or it can be working on one problem while another is being put in and yet another coming out. Professor J. E. Robertson is in charge of design and construction of this computer, which is supported jointly by the Atomic Energy Commission, the Office of Naval Research, and the University of Illinois.

The other new computer under construction in D.C.L. is a pattern recognition computer. This unusual device is not primarily for numerical computation. It is designed to search for, recognize, and analyze visual information — particularly the collision of high-energy particles in bubble chamber photographs. A bubble chamber, of course, is a vessel filled with a superheated



The portion of the new Illinois camputer in frant of the aperator contains 4,000 transistors. There are 26,000 more in the sectian behind him. The camputer will be operatianal in the near future.

liquid that will detect the track (in the form of a string of bubbles) of an ionizing particle moving through it. Visually scanning a million or so such pictures a year, filtering out extraneous data, and evaluating the nuclear interactions in these photographs has been a time-consuming process in the past. The pattern recognition computer will not only offer a solution to this problem, but should be useful in the developing study of better means of designing, constructing, and using digital systems for the processing of photographic data. Professor B. H. McCormick is in charge of the design and construction of this computer, which is supported by the Atomic Energy Commission and the University of Illinois. ◆

U OF I JOINS UNIVERSITIES COUNCIL ON HYDROLOGY

Because of the many different and widely divergent fields involved — such as agronomy, meteorology, engineering, soil physics and chemistry, mathematical statistics, forestry, geography, and geology — hydrology has in the past not had a single, authoritative voice in this country. The rapid growth of interest in hydrology because of the need to develop critical water resources has made it necessary to establish a central body to speak for American universities on the subject. The University of Illinois has accepted membership in this newly formed organization, the Universities Council on Hydrology.

Professor V. T. Chow, head of the Hydraulic Engineering Division of the Civil Engineering Department, has been designated the University of Illinois delegate to the Council. Professor G. W. White, Head of the Department of Geology, serves as alternate delegate. He is an authoritative educator in geology and an experienced hydrologist in the field of ground water and glaciers.

Professor Chow is a well-known figure in hydrology. His method of determining the peak discharge of flow from small rural drainage basins is described in detail in Engineering Experiment Station Bulletin 462, *Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basins* (available for $1.50 from Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana). Professor Chow is now editing a forthcoming handbook of applied hydrology which will be published next year by McGraw-Hill Book Company. ◆

PEOPLE AND PLACES

Professor P. D. Coleman, head of the ultramicrowave research group in the University of Illinois Department of Electrical Engineering, has been named a Fellow of the Institute of Radio Engineers. This is the highest membership grade offered by IRE and is bestowed only by invitation on those who have made outstanding contributions to electronics.

Professor Arthur L. Friedberg has been named Head of the University of Illinois Department of Ceramic Engineering, effective September 1, 1963. He will succeed **Professor A. I. Andrews,** who is retiring at that time.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 4, NO. 2, FEBRUARY 1963

RADIOLOGICAL HEALTH GRADUATE PROGRAM

The University of Illinois Department of Civil Engineering is offering a new program leading to an M.S. or Ph.D. degree in Sanitary Engineering with a specialty in Radiological Health. This program will combine specialized education in the basic and engineering sciences related to radiation control with the general education of the sanitary engineer. Financial assistance can be offered to qualified graduate students under a grant from the U.S. Public Health Service. These fellowships provide for tuition, fees, and monthly stipends ranging from $250 to $400, with an additional $30 per month for each dependent.

Additional information on programs, admissions, and applications is available from Professor N. M. Newmark, Head, Department of Civil Engineering, University of Illinois, Urbana. ◆

NATIONAL ENGINEERS' WEEK

"America's Engineers Build for the Future" is the theme of National Engineers' Week, February 17–23. National Engineers' Week is sponsored each year by the National Society of Professional Engineers.

According to Warren C. Stadden, National Chairman of Engineers' Week, the theme this year was chosen to emphasize for young people now in high school how contemporary engineering knowledge and skill will shape the scientific and technological achievements of the future.

The committee for National Engineers' Week is composed entirely of engineers. Its distinguished membership is an illustration of the important roles engineers are playing in our society: Michael Baker, Jr., consulting engineer; Wernher von Braun, Director, George C. Marshall Space Flight Center, NASA; Governor George D. Clyde of Utah; Rear Admiral P. Corradi, Chief of Civil Engineers, U.S. Navy; Dr. Charles S. Draper, Director, Instrumentation Laboratory, MIT; Dr. Elmer W. Engstrom, President, Radio Corporation of America; Dr. William L. Everitt, Dean of Engineering, University of Illinois; Dr. J. Herbert Hollomon, Assistant Secretary of Commerce for Science and Technology; D. Brainerd Holms, Director, Office of Manned Space Flight, NASA; Dr. Frederick L. Hovde, President, Purdue University; Dr. Eric A. Walker, President, Pennsylvania State University; and Melvin F. Wood, Chief Engineer for the du Pont Company.

National Engineers' Week is held annually during the week of Washington's birthday. The observance features career conferences for schools, exhibits on engineering achievements, guided tours through industrial plants, talks by engineers before student and civic groups, and other activities. ◆

WHAT ABOUT A BOOKLET?

Have you ever wondered how maps of the moon are made? Or how an artificial satellite could possibly be used in mapping far away and inaccessible places? These two questions are asked at the beginning of a booklet called *What About a Career in Photogrammetry?* published by the American Society of Photogrammetry and written by a four-man committee under Dr. H. M. Karara of the University of Illinois Civil Engineering Department. Mr. Gordon Gracie, another of the committee members, is also on the Civil Engineering staff.

The booklet explains what photogrammetry is, how it developed, what a photogrammetrist does, the instruments he uses, where he can work, and how to become one. Dr. Karara, whose work was reported in the November 1961 *Engineering Outlook,* has been commended by the Society for his role in the writing and production of the booklet. Anyone interested in a free copy of the brochure should write to: American Society of Photogrammetry, 44 Leesburg Pike, Falls Church, Va. ◆

Engineers and scientists frequently encounter beouty when they are seeking knawledge. Sametimes that beauty of the physicol world can be recarded, for exomple by using photomicrogrophy, in the same way that physicol focts are recorded. In this way the ort — as distinct from the science — of photomicragraphy hos become a rewarding hobby with many scientists ond engineers. This phatamicragraph of an electran beam pattern arising during on olignment af an electron microscope wos taken by C. E. Feltner, reseorch assaciate in the U of I Department of Theoretical ond Applied Mechanics.

HIGH TURBO-CHARGING OF DIESEL ENGINES

Recent research at the University of Illinois shows that a new level of diesel engine performance may be available in the near future.

Four-stroke gasoline engines that develop one or more brake horsepower per cubic inch of piston displacement have been produced for a number of years. These include engines for racing cars, larger aircraft engines of the reciprocating type, and, more recently, passenger and sports car engines. According to an investigation by Professor W. L. Hull of the University of Illinois Department of Mechanical and Industrial Engineering, it should be feasible to develop at least one horsepower per cubic inch of piston displacement in a production four-stroke diesel engine.

A single-cylinder, open combustion chamber diesel engine was equipped so that boosting the intake air pressure by means of an exhaust-driven turbosupercharger could be simulated. Compressed air was used at the intake, and the exhaust back pressure was controlled in proportion to that required to operate the turbine. The intake air temperature was regulated by using electric heaters. The intake air was boosted in excess of three atmospheres pressure and the effect of using aftercooling to 200° F. intake air temperature was simulated. These conditions were sufficient to produce one horsepower per cubic inch of piston displacement at 2,600 revolutions per minute speed. In addition to giving very high power output, high supercharging also reduced the fuel consumption per horsepower output by 24 per cent. This was because of the reduced percentage of friction and heat loss from the combustion chamber.

By using aftercooling of the intake air, excessive temperature due to compression can be avoided. This cooling can be accomplished by using either an air-to-air or an air-to-water heat exchanger, the latter being arranged to use cooling water coming from the engine radiator. By reducing this temperature, the specific weight of the intake air is increased further, so that more fuel can be burned, thereby increasing the horsepower still further. This also saves on the amount of work expended in supercharging, accounting partly for an improvement in fuel consumption.

High turbosupercharging should allow engine builders to produce more compact engines of lighter weight and lower cost per horsepower. The cost of operation of such engines should be extremely low because of the improved fuel consumption. In this test, brake mean effective pressures as high as 320 pounds per square inch were measured at 1,800 revolutions per minute, which gave maximum gas pressures in the engine cylinder of 2,800 pounds per square inch. This required making some of the engine parts considerably stronger to withstand the high stresses. The thermal efficiency of the engine ran as high as 39 per cent. A multicylinder engine of the same bore and stroke should be even better than this because multicylinder engines have a lower percentage of friction and heat loss than a single-cylinder engine.

Professor Hull presented a technical paper on this research, "High Output Diesel Engines," at the annual meeting of the Society of Automotive Engineers in Detroit on January 16. Copies of this paper are available from the SAE, 485 Lexington Avenue, New York City. ◆

TAKING THEIR TESTS TOGETHER

A university is like a magnet. It attracts scholars, researchers, and ideas from all over the world. An unusual example of this occurred recently when an experimental engine and an engineer who contributed to its design came to the University of Illinois from opposite sides of the world.

In 1947 Mrs. Switlana Winnikow graduated with an

engineering degree from Technische Hochschule, Graz, Austria. She started her career as an engineer that year with Dr. Hans List, an Austrian engine designer of great fame. During 1947, '48, and part of '49 she cooperated on the development of an experimental 2-cycle, 1-cylinder diesel engine.

From Austria the Winnikow family went to Australia, where for eight years Mrs. Winnikow worked as a design engineer for the government. In 1957 they came to the United States because Mrs. Winnikow wished to further her education at the University of Illinois. She enrolled as a graduate student in the Department of Mechanical and Industrial Engineering, and is now preparing for her preliminary examination for the doctoral degree. Although the department has had two women completing their M.S. degrees in its long history, Mrs. Winnikow is the first woman doctoral candidate in mechanical engineering at the University of Illinois.

Meanwhile the engine she had worked on in Austria had come to Peoria, Illinois. It had been purchased by the Caterpillar Tractor Company for testing purposes, and was then loaned to the Internal Combustion Engine Laboratory of the U of I Mechanical and Industrial Engineering Department for further study.

Mrs. Winnikow is now conducting tests on a special heat transfer apparatus she has designed to fulfill the research requirements for her Ph.D. in mechanical engineering. Down the hall a short distance the engine she worked on in Austria 15 years earlier is being tested by undergraduate engineers. ◆

MUSIC AND MONOTONY

Music, indeed, hath charms. Poets have long told us so. Now a University of Illinois engineer is studying how those charms can be put to work. Stephan Konz, instructor in the Department of Mechanical and Industrial Engineering, is studying the effect of background music on human productivity.

Background music is commonly used in American industry, but the amount of unbiased, impartial, experimental data available on the subject is meager. In the U of I study, two different monotonous tasks were investigated with and without background music to see if distinct differences in time consumed and error rate could be found. The two tasks, one "mental" and the other "manual," were performed by a group of college freshmen.

Men and women were equally affected by the background music. The difference in output between the group with background music and the group without it was highly significant. The average improvement during the period when music was played was 17 per cent for the manual task and 18 per cent for the mental task. The error rate (collected only for the mental task) was neither increased nor decreased by the music.

Detailed results of this study, done in cooperation with Professor Josef Cohen of the U of I Psychology Department, was given by Mr. Konz in a paper in New York City in November at the Annual Convention of the Human Factors Society. Further details on this study are available from Mr. Konz, 228 Mechanical Engineering Building, University of Illinois, Urbana. ◆

ELECTRONICS FOR PEOPLE NOT IN ELECTRONICS

Most chemists, physicists, biologists, and engineers are not electronic experts. This is no more surprising than the fact that most electronics engineers are not experts in chemistry, physics, biology, or in other fields of engineering, but it does cause more problems. Everyone uses "black boxes," those mysterious testing and recording devices essential to most research, but very few know what to do when these electronic instruments fail to function. Two chemists working at the University of Illinois have found a solution to this problem.

Professor H. V. Malmstadt, a chemist who worked with radar during the war, had the original idea and started

Professor Howord V. Malmstadt (left), University of Illinois, and Professor Christie G. Enke, Princeton, test equipment in the course which unveils the mysteries of electronic devices to chemicol, biologicol, medical, and other reseorch workers.

working on the problem more than ten years ago. In 1955 he was joined by another U of I chemist, Professor C. G. Enke, who in 1959 went to Princeton but has continued to spend his summers at the University of Illinois. They developed a course, equipment, and a book on electronics for people not in electronics, and they tested them in a one-semester course for U of I graduate students and in three-week summer courses for men from industry. The course is an integrated system based on laboratory work and presented from the point of view of the user of electronic instruments. Although it will not make him an expert in electronics, the student learns basic rules and facts that will enable him to understand, set up, and service his equipment. He also learns to make alterations or modifications in his black boxes to keep them up to date with his research, as well as how to communicate with the electronics experts he works with from time to time. The book, *Electronics for Scientists,* by Malmstadt and Enke, has just been published by W. A. Benjamin, Inc., New York. Electronic units for the course are produced and sold by the Heath Company, makers of the "Heathkits" long familiar to the electronic and radio fields.

Further information on the over-all program or specific courses at the University of Illinois is available from Prof. H. V. Malmstadt, 306 Noyes Laboratory, University of Illinois, Urbana. Further information on instrumentation may be obtained from the Heath Company, Benton Harbor, Michigan. ◆

SIX-WEEK SUMMER PROGRAM FOR SECONDARY SCHOOL STUDENTS

The Illinois Junior Engineering Technical Society and the National Science Foundation will co-sponsor a six-week summer program at the U of I from June 24 through August 2. Approximately 40 students who will be Illinois high school seniors in the fall of 1963, ordinarily those in the upper ten per cent of their classes, will be eligible for the programs. The deadline for applications is April 1, 1963.

Application forms may be obtained from Professor J. S. Dobrovolny, Director, 117 Transportation Building, University of Illinois, Urbana. The Summer Program, like the JETS Program, is intended to stimulate interest in engineering among outstanding high school students and give them a chance to see for themselves the many career opportunities in engineering. ◆

PEOPLE AND PLACES

Professor C. T. Sah of the University of Illinois Department of Electrical Engineering has been awarded the Browder J. Thompson Memorial Prize by the Institute of Radio Engineers for his paper on "The Effect of Surface Recombination and Channel on p-n Junction and Transistor Characteristics."

Dr. M. E. Wyman, Professor of Nuclear Engineering at the University of Illinois, spent several weeks in January and February in Mexico City advising administrators there on the installation and future uses of Mexico's first nuclear reactor.

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LEONARD COBURN
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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 4, NO. 3, MARCH 1963

10,000 ATMOSPHERES AT –400° F.

Solids, as well as being extremely useful materials, have some strange and wonderful properties that are dearly beloved by researchers in the University of Illinois Physics Department, which has the distinction of containing the world's largest collection of academic people working in the field of solid state physics. While many of the programs are directed toward clarifying problems of potentially practical importance, the major effort is in basic research, in a study of problems which, like mountains, are interesting because "they're there."

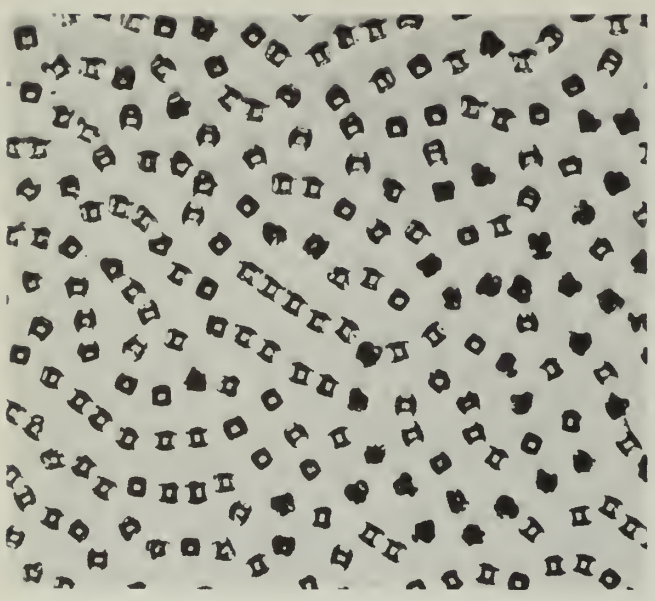
For many years scientists have been curious about the mechanisms involved in the coloration of transparent crystals by ionizing radiation such as X rays. It has been known for decades that most transparent materials, such as simple salts, glasses, or even diamonds, become colored in characteristic ways when subjected to high-energy radiation. A large number of different specific "color centers" have been identified and studied, particularly in the alkali halides (such as common table salt), which have relatively simple crystal structures. The simplest center which has been fully identified is the F- (for *Farben*) center, which is known to be caused by an electron trapped at a vacant lattice site where a negative ion is missing. Other centers, with different characteristic absorption frequencies, result from other types of lattice defects and are frequently quite difficult to identify atomistically.

Even for the simple F-center, one of the most important questions is still quite open — how does the ionizing radiation create negative ion vacancies? At X-ray energies at which coloration occurs, there is simply not enough energy in the incident X-ray photon to knock a heavy negative ion out of its lattice position by a simple collision. Therefore, it has been necessary to hypothesize somewhat more complex mechanisms to explain the formation of negative ion vacancies. Some of these involve the idea of "thermal spikes," localized regions in the crystal which are "heated" by the radiation in which atoms can be "boiled out" of lattice sites. Other mechanisms which have been suggested involve the multiple ionization of negative ions by the incident radiation. The negative ion is thus transformed to a positive ion at the wrong site, and could be expelled by strong electrostatic forces. These alternative mechanisms have been studied by a variety of techniques.

Recent studies by Douglas B. Fitchen, a former U of I graduate student in physics now at Cornell, have shed some light on the subject. This investigation, directed by Professor David Lazarus of the Physics Department, involved measurements of the effect of high pressure on the rates of formation of F-centers in a number of alkali halides at low temperatures. The experiment required equipment for generating pressures of up to 10,000 atmospheres in helium gas. The gas was "pumped" into a small chamber containing the specimen to be irradiated, which was kept at temperatures of liquid nitrogen or liquid helium. The X-ray beam for coloring the specimen entered the chamber through a "window" of beryllium, while the light beam for measuring the amount of coloration passed through two sapphire "windows" set at right angles to the beryllium window. These windows, in order to withstand the pressures involved without blowing out or leaking, were made from optically flat cylinders about ¼ inch in diameter and ½ inch in thickness.

The results of the study showed conclusively that at low temperatures the primary cause of formation of negative ion vacancies could not be the thermal spike mechanism, since application of pressure is known to suppress thermally activated processes in a predictable manner to a far greater extent than was observed. The results for sodium and potassium chloride were quite consistent with the multiple-ionization mechanism. However, for potassium bromide, much larger pressure effects were found, showing that the same multiple ionization mechanism could not be valid for both the chlorides and bromides.

Thus, as in most such investigations, the answering of one question has raised another at least as intriguing as the first, and considerable further study will be necessary before the exact mechanism can be deduced. ◆



This may oppeor to be an aerial view of a porking lot, but it is actuolly o graup of lead titanote crystals, magnified 700 diameters, growing an the surfoce of malten gloss. This study in the University of Illinois Deportment of Ceromic Engineering, sponsored by the AEC, is designed to goin a further insight into the nucleotian ond growth of crystals in gloss systems.

MEASUREMENTS ON SUPERCONDUCTORS

From theory to complete understanding is often a long step. In 1957 the theory of superconductivity was created at the University of Illinois by Professors John Bardeen, L. N. Cooper, and J. R. Schrieffer. This theory was a major step in the understanding of superconductors, a necessary step for their future applications. In the last five years many research projects have been conducted in the U of I Physics Department in an effort to validate and extend this theory.

The state of superconductivity occurs abruptly in at least 25 of the 68 naturally occurring metals as they are cooled to within a few degrees of absolute zero. At this point, the motion of the conduction electrons changes drastically. As a result, the metal loses all electrical resistivity (currents have been started in rings of superconductor material and have circled undiminished for years), and it becomes a perfect diamagnet (superconductors make good magnetic shields). A large amount of experimental and theoretical evidence obtained in the last ten years has shown conclusively that the underlying cause for these phenomena is the appearance of a gap in the distribution of energy levels which may be occupied by the conduction electrons.

One of the experiments at the University has been performed by Professor Donald Ginsberg and James D. Leslie, a graduate student, to determine the influence of electron concentration and mean free path on the width of this energy gap. The method is to determine the minimum energy which a photon (a quantum of electromagnetic energy) must have to be absorbed in alloys of lead and thallium by exciting an electron over the gap. Using the theory of superconductivity, the results of these experiments have been shown to be in good accord with magnetic measurements of the thermodynamic free energy of the alloys.

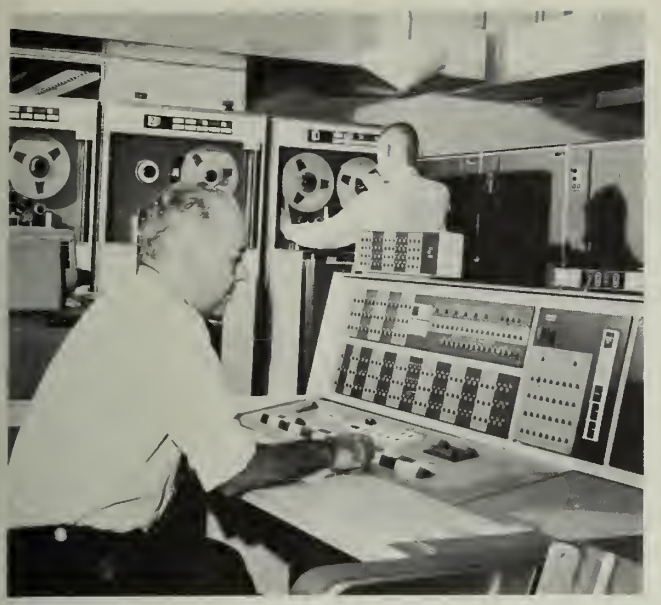
In another series of experiments performed by Professor Ginsberg and a graduate student, Stuart Bermon, the temperature dependence of the energy gap in superconducting mercury was measured. The experimental method involved measurement of the rate at which electrons quantum-mechanically tunnel into the mercury through a barrier provided by a thin insulating layer. The results are in excellent agreement with the theory.

Although there are already many useful applications of superconductivity (for example, in computers and electromagnets), the chief interest at the University of Illinois is in achieving a better understanding of the fundamental phenomena involved. Many other people at the University of Illinois are working in this particular field of interest. Experimental testing of the theory serves to consolidate the gains made by the proposal of the theory and helps to push forward the basic understanding of superconductivity. ◆

TEACHING TAM WITH TELEVISION

For several years the University of Illinois Department of Theoretical and Applied Mechanics has been experimenting with the use of television as an instructional medium. The particular course which has been used is TAM 223, Mechanical Behavior of Solids. This course, covering tension, compression, torsion, bending, hardness, time and temperature effects, stress concentrations, and columns, involves a number of dramatic experiments particularly well fitted to television presentation. The camera allows what amounts to individual instruction, getting in close to a demonstration and showing it to many more students than could actually get close to the work, and expensive or difficult demonstrations only have to be done once. The experiment has been a success and TAM 223 is now regularly taught via television.

A portion of the same course is now being taught by video tape at the U.S. Military Academy at West Point. The tapes were recently licensed by the U of I for use over closed-circuit television for the education of Academy students. The video tapes are also being listed with the National Educational Television and Radio Center so they will be available for use by other educational institutions. ◆



The Notional Science Foundotion hos provided the University of Illinois with its first outside gront for reseorch in nucleor engineering. The gront is for o two-yeor study on computer-controlled reoctor fuel monogement. According to the director of the study, Professor F. T. Adler of the Physics Deportment, "The improved economy of the power reoctor of the future moy depend upon the best utilizotion of the nucleor fuel. This requires shifting of fuel elements, ond only modern computers con economicolly predict the best way to hondle this problem. Therefore the first outside-sponsored UI nucleor engineering reseorch progrom depends upon the use of o computer to simulote o power reoctor." The photogroph shows the computer to be used, the University's new IBM 7090.

JETS PROGRAMS IN ENGINEERING FOR HIGH SCHOOL STUDENTS

The State of Illinois Junior Engineering Technical Society, with the cooperation of the faculties of three campuses, will sponsor three separate educational and orientation programs in engineering for high school students this coming summer. The first of these JETS-sponsored courses, held at the U of I last summer, was such a success that the program has been expanded to three campuses this year. The programs, from July 28 through August 10, will be held at Bradley University in Peoria, the U of I Undergraduate Division at Chicago, and the U of I College of Engineering at Urbana. There will be no tuition fees, but charges will be made for room and board and for instructional supplies. Scholarships to cover these charges are available for some of the participants.

The deadline for applications is April 10, and appointments will be announced about May 1. All applications or requests for further information should be sent to State Headquarters, Junior Engineering Technical Society, 313 Transportation Building, University of Illinois, Urbana. ◆

THE NEED FOR ENGINEERING TECHNICIANS

A total of 14,270 engineering technicians were graduated in this country in 1960–61, according to the Manpower Studies Committee of the Technical Institute Division of the American Society for Engineering Education. Most informed estimates put the ideal number of technicians at two to three for every engineer; in view of the 31,900 first engineering degrees granted in 1960–61, there should have been 60,000 to 90,000 technicians graduated instead of 14,000. In fact, if the nation were graduating as many engineers as our growing economy needs (more than 80,000 a year), we should be getting 160,000 to 240,000 technicians instead of 14,000!

This ratio is only an estimate, but it still gives an idea of the magnitude of the problem. The University of Illinois has long taken a position of leadership in developing programs for training high-level technicians in the State of Illinois. Recently, for example, the Illinois State Board of Vocational Education made two grants to the U of I Department of General Engineering, one to aid in the current studies for development of programs in engineering technology for Illinois junior colleges, and the other to conduct a technician-need study for Vermilion County in Illinois.

The U of I is matching funds with the first grant to continue the study of the last several years to develop two-year programs for high-level technicians in mechanical, electrical, and civil engineering technology. These programs will serve as guides for Illinois junior college engineering technology curricula in the future.

The technician-need study will consist of a survey of Vermilion County to determine the need for technicians by number and type in the various industries located there. The Danville Junior College in Danville, Illinois, will aid the University of Illinois in this study.

Further information on engineering technician studies at the U of I is available from Professor J. S. Dobrovolny, Head, Department of General Engineering, University of Illinois, Urbana. ◆

WE HOPE IT'S ANGELFOOD

An engineering student at the University of Illinois has his cake and eats it too.

Many small engineering schools offer their students individual attention, small activity groups, and short distances between classes; a large engineering school traditionally offers its students outstanding instructors and facilities, and diversified educational opportunities. The U of I College of Engineering is organized in such a way that it offers the advantages of both to its students.

The University of Illinois, with 31,000 students and 12,000 staff members, is a large university. It includes 17 colleges and a number of other schools and institutes. It has three campuses, two in Chicago and the main one at Champaign-Urbana. The main campus contains over 3,000 acres, 535 of which compose the central campus area. This area contains most of the 650 buildings on the main campus.

The College of Engineering is also large. It covers approximately eight square blocks at the north end of the Champaign-Urbana campus. This area contains 27 buildings, which house 1,200 faculty members, 3,650 undergraduate students, and 1,200 graduate students. The College also has a number of other research sites in Illinois such as the Wullenweber Antenna site (*Outlook,* November 1962) and the Radio-Telescope site (*Outlook,* November 1962).

The College of Engineering is divided into departments which grant both graduate and undergraduate degrees in addition to conducting research programs: Aeronautical and Astronautical Engineering; Ceramic Engineering; Civil Engineering; Electrical Engineering; General Engineering; Mechanical and Industrial Engineering; Mining, Metallurgy, and Petroleum Engineering; Physics; and Theoretical and Applied Mechanics. Associated groups include Agricultural Engineering (its budget is in the College of Agriculture, its students in the College of Engineering); Chemical Engineering (which, while part of the College of Liberal Arts and Sciences, conducts much of its research under the Engineering Experiment Station); the Coordinated Science Laboratory (dedicated to interdisciplinary research); the Nuclear Engineering Program (guided by an interdepartmental committee); the Digital Computer Laboratory (many of whose staff members hold joint appointments in D.C.L. and the College of Engineering); and the Materials Research Laboratory (an interdisciplinary laboratory, now in existence as a program, of the departments of Ceramic Engineering; Chemistry and Chemical Engineering; Electrical Engineering; Mining, Metallurgy, and Petroleum Engineering; and Physics).

The large size of the University and the College offers many advantages: outstanding personnel in every field; research programs that sustain and contribute to the education programs; and a tremendous variety of facilities not found at smaller institutions. Yet the individual student is not lost in numbers. Half the classes have less than 20 students, and the average size is 24. Clubs, activity groups, and housing units are purposely kept small and congenial. Any student who wishes can have individual counseling on coursework or personal problems, in addition to help from a faculty advisor for curriculum planning.

Because of the University's size, students get the good cake of outstanding instructors and facilities; because of the forethought of its planners (who have provided for the University's growth in the coming years), they also get the icing — individual attention and an atmosphere that is friendly and congenial. ◆

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 4, NO. 4, APRIL 1963

MIDWEST SPACE MONTH

Public attention on the nation's space effort generally centers on Cape Canaveral. As the launch point, "the Cape" is the stage for moments of great drama. But Cape Canaveral is like the tip of a spear — it is the foremost point in our attention, but behind it, providing the weight to push it along, is an ever broadening spear blade.

The blade behind the launching sites consists of research and development laboratories in colleges, universities, and government and industrial installations all over the country, and of a steady flow from the universities and colleges of young people qualified to work in the space effort as engineers and scientists. One major contributor to the space effort is the University of Illinois.

The month from April 9 to May 9, 1963, has been designated Chicago and Midwest Space Month to pay tribute to the area's contributions to the nation's space program. One of the events during this month will be the Third National Conference on Peaceful Uses of Space, to be held in Chicago May 1–9. The University of Illinois will be a participant in these programs, presenting a session May 7 on the role of universities in space research.

Engineering Outlook is observing this occasion by departing from its usual editorial policy in three ways. First, this issue is centered on a single topic — the contribution of the University of Illinois to the space effort. Second, a broad variety of areas outside of the College of Engineering is being reviewed to give a sample of the total research effort related to space. Finally, the magnitude and variety of the University's contribution to the space effort has made necessary the doubling of the size of this issue. Even then, we can present only a sampling of one of the largest university research efforts in this country.

Last year the University of Illinois spent $31,241,308 on research, a large proportion of which came from outside sponsorship. Dollars, however, cannot fully give the measure of a research program. Dollar values can't be assigned to studies that may contribute to overcoming the communications blackout while an astronaut and his capsule undergo the hazards of atmospheric re-entry, or to research that has helped to make our Polaris missiles such highly effective deterrent weapons. Research means ideas, and ideas can bear fruit that cannot even be visualized now.

Nearly every area of science and engineering at the U of I is doing research of significance to space exploration. The Digital Computer Laboratory of the Graduate College has long been making significant research contributions, and computers have become essential to the control of space travel. Researchers in agriculture are studying nutrient requirements of humans under conditions of dietary stress, and food technologists are doing advanced work on food dehydration and preservation. In radiology, studies are being made on the correlation of environmental conditions with changes in biological systems. In microbiology and in botany an assortment of projects on microorganisms may produce important information in the development of a space ship microcosm that can support man during long space voyages. In physiology and biophysics such research as a project on the effects of acceleration on organs in both man and animals may produce important new knowledge.

In a press conference in Chicago last December, NASA Administrator James E. Webb said ". . . any efforts you make and any funds you invest in increasing the exchange of ideas and information between the business community and the scientific community represented by the universities and the research institutes will prove in the long run of great value to the future prosperity of this area and of the nation."

Midwest Space Month is designed to aid in this communication between industries and the great universities of the Midwest. This issue of *Engineering Outlook* is intended to help in this worthwhile effort by describing the major role the University of Illinois is playing in space research and education. ◆

Breathing is something earthlings take for granted, but it looms as a problem for a man in space. Here, two test subjects are fed oxygen in a depressurization chamber at the University of Illinois Aeromedical Laboratory in Chicago.

PEOPLE ARE OUR MOST IMPORTANT PRODUCT

With one of the largest, most diversified research programs in the United States, the faculty of the University of Illinois still believe that the University's most important product for the space effort is people — highly educated young men and women who year by year take their degrees from the University and move into full participation in the nation's space research and development programs. Keen young minds with solid education in the sciences and in engineering have no substitute. Last year the University of Illinois led the nation in the number of engineering degrees awarded — 1,090. On December 18, 1962, James E. Webb, Administrator of the National Aeronautics and Space Administration, said in Chicago that one significant contribution to the space effort is "to furnish the highly trained scientific and engineering brainpower essential to the success of the space program. . . . we are particularly interested in seeing a sharp increase in the number of doctor's degrees granted in engineering, mathematics, and the space sciences, as only in this manner can we meet our national goals in space exploration." Last year the University of Illinois was second only to M.I.T. in number of doctorates awarded in engineering, with a total of 94. In mathematics, the U of I awarded 17 doctorates last year, and in physics and chemistry, 74 doctorates.

A recent College of Engineering survey has shown that in the last five years more than 26 per cent of U of I engineering graduates have gone into the aerospace industry and more than 11 per cent have gone into electronics and instrument work. These figures include graduates from many fields of engineering. Others working for the federal government and in research are also involved in space work.

High percentages of engineering graduates in space work might be expected, but fields outside of engineering are also making significant contributions. As a matter of policy, research and educational programs at the University of Illinois are designed to sustain and support each other. The scope of aerospace research-related projects reported here, while but a small sampling of the projects in progress, gives some indication of the scope of the educational programs that are contributing to the American aerospace efforts. ◆

KEEPING OUR ASTRONAUTS ALIVE

What will happen to man's heartbeat, circulation, respiration, eyesight, hearing, and total body reactions during the extreme rigors of space flight takeoff? What will be the effects of the vibrations, jolts, and jars of his trip through the earth's atmosphere to get into the calm of space, and of the return trip as the space ship decelerates to a landing? These questions and others like them have been studied for many years by Dr. John P. Marbarger, director of the University of Illinois Aeromedical Laboratory in Chicago.

Dr. Marbarger has been conducting research in space medicine since 1943. In 1950 he conducted one of the first symposiums on space medicine in the United States (and the first at an American university) at the U of I Medical Center in Chicago. He and his research team made important contributions toward the launching and recovery of live animals which first paid off in 1959. Dr. Marbarger's early work in this line included working out the problem of recovering electrocardiographic signals from the animal rocket passengers; helping to prepare and install equipment that would radio back information on the physical condition of the monkeys; calculating the amount of oxygen needed to keep the monkeys alive in their sealed capsules; and measuring the effects on animals subjected to weightlessness.

Some of Dr. Marbarger's more recent and most interesting studies have concerned the effect of high altitude on the body and its senses, human tolerance to heat over extended periods of time, decompression sickness, and the adoption, through miniaturization, of medical electronic devices for use in rocket experimenting.

Dr. Marbarger is representative of the many kinds of men working in the space program at the University of Illinois and in many other places around the country — a man with his feet on the ground and his eyes on the stars. These men will not reach other worlds themselves — but because of them, other men will. ◆

SCIENCE AND ENGINEERING WEEKEND MAY 10 AND 11

The laboratories and classrooms where some of tomorrow's von Brauns and von Karmans are being educated will be open to the public on May 10 and 11. This year the exposition will be a combined effort of four groups: the Illinois Junior Academy of Science, the Junior Engineering Technical Society, the College of Engineering, and the College of Veterinary Medicine. Visitors will be asked to park their cars in the lots of the new Assembly Hall south of the stadium. They can first visit the IJAS displays in the Assembly Hall, and then take shuttle buses to all other points on campus. The JETS displays will be in the Illini Union, and as always before, the classrooms and laboratories of the engineering campus and the vet medicine campus will be open for inspection. The Engineering College displays make up the traditional Engineering Open House held every spring. Science and Engineering Weekend will be dedicated to giving guidance to students in selecting the right career field, offering counseling on housing, curricula, and such matters, and showing guests the latest educational and research techniques and discoveries at the University of Illinois. It will also make it possible for visitors to see how Illinois' high school and college students are preparing themselves to participate in and help to create the space age. ◆

SCIENCE, TECHNOLOGY, AND SPACE NAVIGATION

According to Einstein's general theory of relativity, the spin axis of a gyroscope moving around the earth should change in direction a few seconds of arc over a year's time. This change is so small that it could not be measured with conventional gyros, which drift much more than that in one day. There is now, however, a gyro available that is very much different from older, conventional types. The electric vacuum gyro, developed over the last five years in the University of Illinois Coordinated Science Laboratory (C.S.L.), is potentially sensitive enough to measure such a small drift rate. C.S.L. is presently engaged in a study of the feasibility of putting an electric vacuum gyro in orbit around the earth to attempt such a measurement.

The electric vacuum gyro was invented by Dr. Arnold Nordsieck, who was a U of I faculty member from 1947 to 1961. His concept has been translated into an elegant precision instrument, originally for nautical navigation, by a group of C.S.L. researchers under the leadership of Professor Howard Knoebel. The inherent precision of the instrument promises many applications in the future, including use for space flight navigation.

Basically the gyro consists of a two-inch beryllium ball — balanced and spherical to within a few millionths of an inch — suspended by electric fields in an ultra-high vacuum (about one thousandth of one billionth of atmospheric pressure). This rotor is brought up to its rotation speed by induction coils which produce a spinning electrical field. After a few minutes of initial acceleration, the power to the coils is turned off, allowing the ball to "coast," spinning a few thousandths of an inch away from the walls of its chamber. Effectively isolated from the rest of the universe, the rotor will go on spinning for years.

In the laboratory version, two pairs of mutually perpendicular photomicroscopes, which are focused through sapphire windows in the ceramic housing, read position data from a zigzag line etched on the equator of the ball. The entire gyro assembly is placed on a two-axis gimbal which follows the motion of the rotor spin axis. The motion of the gyro relative to the stars can then be measured from the gimbals.

A careful sequence of refining and testing have resulted in excellent performance figures which are continually being improved. Even in its present form, performance is far better than any other gyro being produced. Still better performance is expected when presently planned modifications are introduced. One of these ideas, for example, is the fabrication of a hollow rotor that is so preshaped that it will become perfectly spherical under the natural deformation of high speed rotation. Such modifications will improve the present performance capabilities of the gyro to the point where the incredible accuracy requirements of the relativity experiment in space could be fulfilled. ◆

The heart of the electric vacuum gyro is the rotor, shown with supporting electrodes and ceramic spacers during assembly into the demountable vacuum housing.

AN ENGINE FOR SPACE TRAVEL

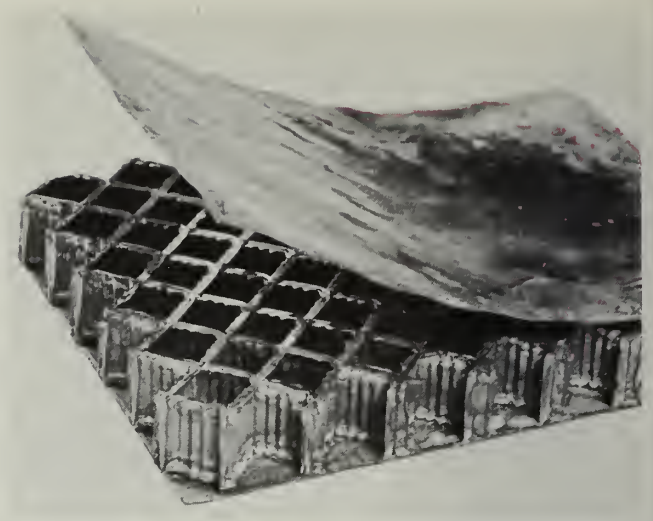
For most people, the term "fuel" refers to materials that will release their stored energy when they are burned. For the engineer interested in space vehicle propulsion, however, it is not a good definition. One reason is that combustion produces heat which may be wasteful of energy, so the space drive designer is much more interested in engines that propel without any burning process being involved. A number of such non-combustion engines of different types are being studied today, one of which is an electrical engine that uses liquid metals as fuel. For three years a group of researchers in the University of Illinois Department of Electrical Engineering, under the direction of Professor Charles D. Hendricks, Jr., have been studying the basic physics of liquid metals for use as working fluids in thrust-producing engines.

Experiments involve placing an electrical charge on tiny droplets of the liquid metal and accelerating the droplets by electric fields. Used in space, this thrust would produce an equal and opposite reaction that would propel the space vehicle. The droplets are produced by maintaining a hollow conducting needle at a high potential as molten metal alloy is permitted to flow through it. The droplet emission process is studied by means of photomicrography, mass spectrometry, and other techniques.

While the thrust produced by this system is small, such a device would lend itself well to interplanetary flight. Chemical rockets, which have high thrust, have low efficiency and can operate only for short lengths of time; the liquid metal engine has high efficiency and can operate for long periods of time. According to Professor Hendricks, "It is almost a certainty that space vehicles will use electric engines of one sort or another in the future. Such engines look promising because of their high efficiency and because their thrust can be better controlled than it can with other types of drives." ◆

GLUING SPACECRAFT TOGETHER WITH CERAMICS

Spacecraft and supersonic aircraft body panels must be light, strong, and heat resistant. One method of making panels that have all of these characteristics is to bond thin inner and outer metal skins to a metal honeycomb, but the adhesive must be able to withstand temperatures of many hundreds of degrees created by aerodynamic heating and also be able to match the coefficients of thermal expansion of the materials it joins. A group of researchers in the University of Illinois Ceramic Engineering Department under the direction of Professor J. A. Nelson have just completed an Air Force research study contract on this problem.



Ceramic adhesive banded haneycomb sandwich with top skin pulled back ta reveal the interiar structure.

Panels of honeycomb structure are several times stronger than solid steel panels of equivalent weight, but their high-temperature strength is dependent on the quality of the adhesives bonding the honeycomb and facing plates together. Professor Nelson and his group studied ceramic bonding materials and combinations of ceramic materials and metal powders that exhibited shear strengths exceeding 3,000 p.s.i. at 1,200° F. and 800 p.s.i. at 1,500° F. Specimens overlapped and bonded with such adhesives were bent more than 90 degrees without breaking. The study has raised the possibility of joining metal parts with combinations of ceramics and metals in an operation similar to brazing, except that it does not have to be carried out in a controlled atmosphere, which necessitates expensive, special furnaces and auxiliary equipment. ◆

ANSWERS THAT ARE STILL UP IN THE AIR

Someone has said that the worst thing that could happen to man in exploring space would be to arrive at a completely water-covered planet, because we know less about the oceans than we do about outer space. It is just as fair to say that we know less about the oceans of upper atmosphere around us than we do about outer space. One of the reasons for this is that space is "simpler" than the upper atmosphere. The ionosphere is a belt of several (recognizably different) layers of ionized air that surrounds the earth. It ranges from 30 to 200 miles up, varying in height and make-up in different places, different layers, different times of day, and at different seasons. Today the ionosphere is generally associated with three things: it makes long-distance radio communications possible by reflecting or refracting radio waves back to earth; it protects man and animals from harmful radiation from the sun and influences weather conditions;

and it poses many more questions than we can yet answer. Some of the means of getting these answers are currently being explored by Professor Sidney A. Bowhill of the U of I Department of Electrical Engineering.

Professor Bowhill is an aeronomist, a man who studies the physical and chemical processes of the upper atmosphere. Aeronomy is an interdisciplinary field lying between physics, chemistry, electrical engineering, meteorology, and aeronautical engineering. The aeronomist studies the ionsphere in two ways: from the ground, with such means as radio reflections (*Outlook,* June 1960); and with rockets (*Outlook,* January 1961). Both methods offer means of getting data pertaining to the many questions still to be answered, all of which may be oversimplified into this broad question: how is the ionosphere formed, how does it disappear, and how can man best use it?

Although much can be learned from the ground, the modern rocket probe technique gives the aeronomist the precise information he needs. A rocket can determine the density of every layer it passes through and bring back analyses of each layer in terms of the number of electrons and positive ions present. Professor Bowhill is presently engaged in formulating recommendations for the National Aeronautics and Space Administration on the number and kind of rocket probes that should be used in a study of the lower ionosphere (30 to 100 miles up). This study will be made during the International Quiet Sun Year (IQSY) from January 1964 through December 1965, a scientific program in which the University of Illinois will play a major role.

The currently increasing interest in aeronomy offers hope that a better understanding of the ionosphere will show new ways to use and benefit from it. Someday, in fact, the aeronomist may find a means that will permit us to do something about the weather instead of just talking about it. ◆

NO NEWS IS NERVE-WRACKING

There were many anxious moments when astronauts John Glenn and Scott Carpenter re-entered the earth's atmosphere. For a time it looked as if Glenn's heat shield might have come loose, and it seemed possible that Carpenter's attitude control system was out of fuel. No one knew for sure because in both cases communications with the ground were broken completely as the blunt nose of the space capsule generated strong shock waves with a more than three hundredfold increase in pressure occurring within a few thousandths of an inch. This rapid compression heated the air to more than 8000° F., hot enough to cause considerable ionization, a separation of electrons from the molecules and atoms of air. As this heated, electron-filled gas or plasma flowed around the capsule, it formed a sheath which blocked radio communications for several minutes until the capsule slowed down. Luckily both astronauts got down all right, but their problems called attention to the seriousness of the communications blackout during reentry. Recently a study related to this problem was cooperatively conducted at the University of Illinois by members of the Gaseous Electronics Laboratory of the Electrical Engineering Department and members of the Shock Tube Laboratory of the Aeronautical and Astronautical Engineering Department.

The study involved directing microwave pulses into oncoming shock waves. The 50-foot-long shock tube, capable of generating waves moving at Mach 17 at a pressure equivalent to an altitude of 29 miles, was used as a waveguide for the microwave pulses of 6 to 100 kilowatts. The pulse was triggered when the shock front was in different positions relative to the measurement station. Two pulse frequencies were employed in these experiments: one to probe the shock wave in an effort to unlock its secrets, and the other to attempt to modify the plasma.

Although all the phenomena shown in these experiments are not yet understood, the tests showed that directing microwave pulses into the shock wave produced some measurable effects. Pulses of less than 50 kw caused the recorded light output of the shock front to change considerably. An increased reflectance of the diagnostic microwave signal behind the shock front was obtained from low power pulses and shock Mach numbers ranging from 11 to 13. Studies such as these may soon show how to keep in constant touch with our astronauts, as well as teaching us something about the ionosphere that surrounds us. ◆

A SUMMARY OF ENGINEERING RESEARCH FOR 1962–63

This issue of *Engineering Outlook* gives some examples of the educational and research programs related to the field of space research and development on the University of Illinois campus. A complete listing of the nearly 500 projects the College of Engineering alone engaged in during fiscal 1962 is available in *A Summary of Engineering Research 1962–63.*

A summary of each project and a list of publications resulting from the research during fiscal 1962 are included in the *Summary.* The descriptions list the objectives, achievements, and present status of each project. The names of the investigators are listed and the chief investigator is identified for each project.

This publication is available without charge from the Engineering Publications Office, 112 Civil Engineering Hall, Urbana, Illinois. ◆

U OF I ANTENNAS PLAY SEVERAL ROLES IN THE SPACE PROGRAM

The U.S. Atlantic and Pacific satellite tracking ranges are being equipped with special conical antennas invented at the University of Illinois. These frequency-independent antennas, similar to those now used on the Transit series satellites and planned for use on future generations of the Ranger moon probes, will be employed as feeds for the large dishes of the tracking ranges.

Log periodic and log spiral antennas, which were invented at the U of I in 1954 and 1955, are still under development in the Electrical Engineering Department's Antenna Laboratory. At the University they are used in the line feed (286 log spirals in a linear array) for the U of I radio telescope, which will be used to map extragalatic radio sources, and as a feed (a paired log periodic dipole array) for the 28-foot parabolic dish antenna, which is used to monitor signals reflected from the moon. The log spiral antennas are particularly well adapted to space applications. They can receive signals over an extremely wide band of frequencies and for any arbitrary orientation of the input signal. These qualities make them ideal for use on satellites and on satellite trackers, where the direction from which the signal comes, as well as the polarity of the signal, changes constantly. ◆

ULTRA-HIGH VACUUM AND THE MAKE-UP OF THE ATMOSPHERE

For some years a program on the production and measurement of ultra-high vacuum has been carried out by the vacuum instrumentation group of the University of Illinois Coordinated Science Laboratory. The vacuum systems which are involved are anywhere from a few inches in diameter to several feet in linear dimension. Within such enclosures pressures as low as 10^{-12} Torr have been achieved. Compared with the density at atmospheric pressure, only one molecule remains for every million billion molecules which were originally present. It is the objective of this effort, guided by Professor Daniel Alpert, to be able to measure accurately not only the total pressure in this range, but also the partial pressures of each of the constituent gases in the system. Nature provides a vacuum system which ranges from 10^{-4} Torr at an altitude of 50 miles above the earth's surface to 10^{-10} Torr at 1,000 miles altitude. As one gets farther from the earth this continues to decrease to a value of about 10^{-16} Torr in outer space, which corresponds to a density of one atom per cubic centimeter. Among the properties of the atmosphere which are as yet only vaguely known and understood are the constituents of the upper atmosphere at altitudes above 50 miles, both for the neutral gas molecules or atoms and for the charged particles (ions and electrons) which play an important role in the propagation of radio waves and optical radiation through the atmosphere. Since the pressure ranges are similar, it should not be surprising that the first techniques used for measuring the composition and density of the upper atmosphere were those which were earlier developed in the laboratory; however, many problems remain, both in the instruments used and in our knowledge of the upper atmosphere.

A program recently undertaken at the Coordinated Science Laboratory has as its objective a study of new techniques for measuring total and partial pressure both in the laboratory and in space. Already two new instruments have been developed at C.S.L. which extend the range of pressure measurement by one or two orders of magnitude over previously accepted gauges. Studies with these gauges have indicated the nature of some of the limitations to be expected when such devices are flown in a satellite. A careful review of existing efforts to determine the composition of the atmosphere at high altitudes will be made, and new concepts for carrying out such experiments will be considered. These studies of the upper atmosphere will shed new light on such questions as the propagation of electromagnetic radiation through the atmosphere, the drag on satellites in orbit, and a more precise understanding of the ocean of gas in which we live. ◆

ROCKET PROPULSION SYSTEM DESIGN

The technique of clustering rocket engines to generate enough thrust to lift large payloads into space has been greatly improved with the help of a theory developed at the University of Illinois. One of the problems caused by the clustering arrangement is the severe "base heating" phenomenon which occurs after the rocket gets out of the atmosphere. While still in altitudes where air exists, the jets from the rocket nozzles of the clustered engines stay in individual flow patterns that do not interfere with each other; out in space they "plume," each of them billowing and enveloping a region where the hot exhaust gases recirculate. The tremendous amount of heat this imposes on the base of the rocket can cause the malfunction of control or guidance systems, and may even melt the base and result in the complete loss of the rocket. Quite a few of the early rocket failures in this country have been attributed to this unexpected base heating effect.

The Gas Dynamics Group of the U of I Department of Mechanical and Industrial Engineering (M.I.E.) has been studying problems of this type for a number of years. One of the results obtained from this research is the "base pressure theory," which has established new design criteria for rocket propulsive systems. The theory was developed by Dr. H. H. Korst (Head of the M.I.E.

Department) and other members of the research team.

The Gas Dynamics Group, now under the supervision of Dr. Korst and Dr. W. L. Chow, is also actively engaged in research of a similar but more basic nature on problems associated with separated-flow. The knowledge gained from this research, sponsored since 1959 by the National Aeronautics and Space Administration, should also have extensive applications, particularly in problems related to atmosphere re-entry. The group is also working on problems associated with the directional control of rocket thrust.

A close cooperation exists between this group and the Department of Aeronautical and Astronautical Engineering in the development and use of experimental equipment in the aeronautical laboratories. Recently the two departments jointly received a grant from the National Science Foundation to design and build a space-simulating hypervelocity wind tunnel. This new facility will provide opportunities for U of I students and staff members to obtain a better insight into the space problems that still confront us. ◆

THE DESIGNER'S QUANDARY: STRENGTH WITHOUT WEIGHT

If you had to design a vehicle to carry an engine powerful enough to lift tons of weight into orbit against earth's gravity, you would face an incredibly difficult task. You would have to make every structural component as light as possible and yet strong enough to resist being broken by the vibration of the huge engine before leaving the launching pad. The structure would also have to be built to resist the stresses of lift-off, multi-G acceleration, atmosphere re-entry temperatures, and so on. These are the kinds of problems that face modern aerospace engineers like Dr. Y. K. Lin of the University of Illinois Department of Aeronautical and Astronautical Engineering.

Dr. Lin is engaged in the study of structural response of high-speed flight vehicles to random environmental loads. Such loads, which are imposed on the vehicle by rocket engine noise vibrations, atmosphere re-entry, and flight through the atmosphere, can only be determined statistically. Dr. Lin attacks such problems by concentrating on reasonably simple but representative structures, an approach that shows up the basic problems involved in random loading that might otherwise be overshadowed by the complexity of the structure.

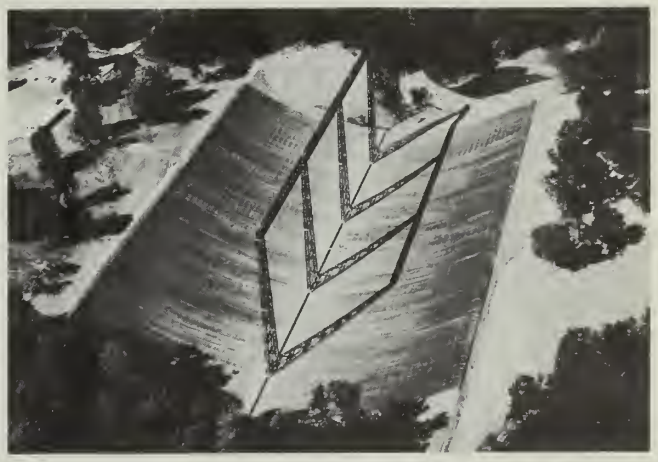
One of the most commonly used structures for spacecraft and high-speed aircraft consists of a flexible metal skin mounted on stronger members called stiffeners. This light construction method is particularly subject to high stresses associated with vibration induced by engine noise. Prof. Lin has developed a method by which one can estimate the stress level in the skin-stiffener construction under the excitation of engine noise while still at the drawing board stage.

The aerospace industry today is extremely interested in stress analyses on the types of structures being used and predictions for those presently being designed. Research and educational programs such as those being conducted by Dr. Lin and others like him at the University of Illinois are contributing to man's ability to make predictions that will prevent the loss of lives, money, and space vehicles. ◆

STUDYING THE ENVIRONMENT OF SPACE

The University of Illinois can duplicate the atmospheric conditions of the fringes of outer space on the ground. The second largest environmental test chamber in the United States is located in the Medical Science Building on the U of I Chicago Professional Colleges campus. The pressure in each of the three compartments of the huge chamber can be controlled to simulate altitudes from sea level to about twenty miles high. Each compartment has its own regulated oxygen supply, and each contains equipment to create temperatures between 30 and 150 degrees.

The chamber is used for medical studies of stresses on animals and humans, testing of protective clothing, and research on equipment used by astronauts. Its ability to create space-like conditions on the ground will give University of Illinois researchers the opportunity to gain the fundamental knowledge engineers and scientists need to create ground-like conditions in space. ◆



The University of Illinois rodio telescope, located in o reshoped ravine five miles southeast of Donville, Illinois, is used for exploring ond mapping the farthest reaches of the universe. The telescope's curved metal mesh reflectar measures 400 by 600 feet. It is capable of "heoring" rodia noises fram galaxies billions of miles away. Both the telescape ond the log spirol antenna feed orroy were designed ot the University of Illinois.

STATEMENT FROM THE PRESIDENT OF THE UNIVERSITY OF ILLINOIS

Space Month provides an excellent opportunity for the Middle West to examine its achievements, its resources, and its opportunities in relationship to the new frontier — the exploration of outer space.

At the national level, among leaders in business, industry, education and government, it is an acknowledged premise that in the education of specialists — engineers, scientists, teachers, and administrators — and in the supply of new ideas through research, the universities of the nation have a major role. They must be counted upon both in the enlargement of knowledge about space and in the formulation of activities for the utilization of that knowledge.

The University of Illinois, with its traditional readiness to deal with new challenges in all fields of learning, has already made a number of contributions to space science and technology. This current edition of the *Engineering Outlook* is an interesting sample of what is now going on and what is planned for the future.

Not all space-related programs and activities at the University of Illinois can be identified in one article. Three basic aspects of the research and education related to space are here reflected, however. One is the far-ranging lines of interest — from radio astronomy to environmental physiology. A second is the interdisciplinary character of space science. Finally, the capabilities in space research are necessarily rooted in the basic strength of a university's total research and education activity.

Hence, we may hope that Space Month will not only focus on the universities' importance in the exciting new developments in space knowledge, but also demonstrate clearly the universities' place in research and economic development.

The large complex university is not only caught up in the changing times; it is one of society's instruments for change — in science, in the development of new ideas generally, and in appraising the influence of those ideas upon human behavior.

Here we have the great contemporary challenge to our universities — they must continue their historic roles in instruction and research on a broad front and at the same time meet the widening demand for the application of their multiple capacities to the human needs of the nation and the world.

The challenge is not for the universities alone, however — it is for the people, for government, for business and industry. Institutions *per se* do not have needs; rather, the society they serve has needs.

For our part, at the University of Illinois, we are prepared further to develop the means to assist Illinois and Midwest industry to build up a research and development capacity that can yield great economic, social, and educational benefits to the entire region and especially to the people of Illinois. ◆

David D. Henry
President
University of Illinois

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MIDWEST SPACE MONTH

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VOL. 4, NO. 5, MAY 1963

STILL USING THAT GREASY ORGANIC STUFF?

One of the many problems that face man on the threshold of space is how to find or create lubricants that will work both at ordinary temperatures and at temperatures up to 1,500° F. under air pressure or in a vacuum. Ordinary oils, greases, and synthetics do not fill the bill. An answer to this problem is being sought in the University of Illinois Department of Ceramic Engineering by a group under the direction of Professor J. A. Nelson.

This is the kind of modern day problem that faces the ceramic engineer, who is playing a major role in the space program and other areas where heat is a factor. This particular project has developed along two principal lines: (1) the investigation of ceramic binders, such as specially formulated glasses, to hold promising dry film lubricants to the metal surfaces where lubrication is required, and (2) single-phase ceramic lubricants which would be self-bonding.

In the initial phase of the study, lead sulfide was used as the main lubricating component in a materials system which used boron oxide as the bonding agent. Because of the variation in the coefficient of friction over the temperature range in question and the partial conversion of lead sulfide to lead sulfate, improved lubrication was sought in other materials. Minerals such as mica (cleavage in one direction), rutile (cleavage in two directions) and fluorite (cleavage in three directions) were studied to correlate the cleavage characteristics with lubrication. The single-phase ceramic lubricants under investigation are mainly glassy in nature, with the emphasis at the present time on halogenated glasses.

In order to evaluate potential solid film lubricants, special equipment is used to measure the coefficient of friction when the different experimental compositions are applied in thin layers (up to .002″ thick) between metal parts that move at high velocities relative to one another. These tests, which are conducted at temperatures from 70° F. to 1,500° F., have provided information concerning the wear characteristics and the physical and chemical changes of the lubricating systems when they are subjected to simulated service conditions.

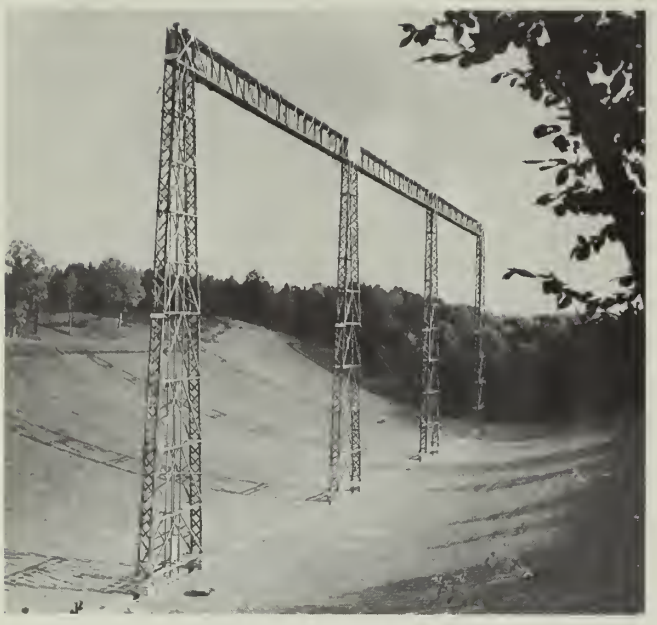
This project, sponsored by the Aeronautical Systems Division of Wright-Patterson Air Force Base, is but one part of an extensive program designed to help us go higher, faster, and farther in spite of the obstacles inherent in such flights — vacuums, near-vacuums, and high temperatures. ◆

SPACE AGE MATERIAL LIGHTER AND STRONGER THAN STEEL

A new model Polaris missile under test recently took some University of Illinois engineering ideas down the Atlantic missile range. The new model has a glass fiber reinforced plastic motor case, a recent successful development which embodies some of the thinking of engineers in the U of I Department of Theoretical and Applied Mechanics (T.A.M.).

The T.A.M. research group, directed by Professor H. T. Corten, has been engaged for several years in a study of the best methods of combining glass fibers and epoxy resin into a strong, light composite for space or earth-bound construction uses. Properly combined, the epoxy resin transforms the bundles of tiny glass filaments from loose layers of pliable parallel fibers into a rigid structure capable of sustaining high loads. The result, glass fiber reinforced plastic, has two great advantages: on a strength-to-weight basis, it is almost twice as strong as steel; or, for the same strength, it is much lighter than steel, an important consideration in rocket design, where every pound counts.

The researchers have concentrated on the internal structure of the plastics to learn which configurations of glass fibers and resins will be likely to contain tiny flaws and cracks. The study has shown, for example, that the uniformity of strength of all the glass fibers is extremely important for high-strength plastics. It has also shown that packing too many fibers into the resin will actually



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weaken the resulting plastic, because the composite will crack if there is not sufficient resin between the fibers.

The motor case of the new Polaris is a structural component of the rocket — its sides form a part of the rocket's outer shell. For this reason the glass fiber reinforced plastic must have great strength, be able to withstand high temperatures (not only from the burning fuel inside but from the friction of air in flights through the atmosphere), and be able to function in three different environments: water, air, and space.

As the recent Polaris test proved, the material is now capable of meeting these requirements, but it will be still better in the future when its properties are better understood and fabrication techniques are improved. For this reason the studies in T.A.M. continue, spurred on rather than slowed by the first successful test of the structural material that promises to be unequalled for high strength and light weight. ◆

ENGINEERING TECHNICIAN CURRICULA STUDIES

Two new curriculum guides for training engineering technicians are being prepared for the U.S. Office of Education by the University of Illinois College of Engineering. This work is the outgrowth of studies made over the last five years at the U of I by the College of Engineering Curriculum Advisory Committee for Programs in Engineering Technology. The chairman of that committee and Head of the Department of General Engineering, Professor J. S. Dobrovolny, is the director of the new study.

The civil technology program, designed as a two-year associate degree program for junior colleges, will include a curriculum, course outlines, laboratory equipment needs, and typical lab layouts. The highway engineering aide program will be designed as twelve-week courses for junior colleges. Consultants from around the United States will help in the establishment of both programs. Both will be planned to produce technologists capable of taking over work formerly done by engineers, freeing them for duties requiring their longer and more intensive education. ◆

ENGINEERING ECONOMY STUDIES

Engineering economy courses at the University of Illinois may be getting harder, but they are getting more useful and realistic. This subject, although an incredibly complex one, can be given only a small amount of time and attention in a crowded undergraduate engineering curriculum. Furthermore, according to a U of I professor, it has not always been taught with emphasis on the most important part of the subject. The professor, William F. Berkow, teaches engineering economy in the Department of General Engineering.

A number of years of experience and a survey study have convinced Professor Berkow that engineering economy courses slanted toward simple quantitative problems, as many are, are emphasizing the less important aspects of the subject. From a recent survey of the thirty Dow-Jones Index companies, he found totals of $66 billion in sales, $27 billion in materials costs, and $19 billion in payroll costs, as compared to the totals listed under the favorite topics of many engineering economy instructors: $4 billion in depreciation, $10 billion in taxes, and $5 billion in net income. The latter topics are admittedly easier to deal with in the classroom, but it is obvious that purchasing and labor costs are much more significant figures, both in size and importance. It is these cost classifications, according to Professor Berkow, that should be emphasized in engineering economy instruction.

Professor Berkow believes that the very factors that are often the reasons purchasing and labor costs are not dealt with extensively are the ones that should be made known to the student. These factors are complex but important; hard to teach but essential to any grasp of engineering economics. Some of them that are important to studies of purchasing are the differences in ma-

terials prices for different quantities and for different finishes; the variations in price structures for specially designed items; the technical, contract, and financial know-how required for effective purchasing operations; and the need for good communications between various types of specialists. Some of the important factors involved in payroll costs are foreign pay rates; indirect fringe benefits; costs of hiring, training, and retraining personnel; and job obsolescence. According to Professor Berkow, a student in an engineering economy class who is not made to consider these problems will not have a realistic picture of the subject when he finishes the course.

Students who study engineering economics at the University of Illinois are now being given strong emphasis on the more complicated but also more important aspects of the subject. Qualified persons needing more detailed information on this program should contact Professor W. F. Berkow, 310 Transportation Building, University of Illinois, Urbana. ◆

A WINDOW TO LOOK OUT INTO THE UNIVERSE

Although space probes by rockets and satellites have received much more publicity, earth-bound radio telescopes are vital scientific tools for the exploration of space. These instruments listen for radio noises from distant galaxies, many of which are invisible to even the largest optical telescopes. Radio telescopes can make space explorations without leaving the earth — provided there is an "open window." The "open window" refers to the wavelengths of the earth's electromagnetic spectrum that have been reserved for scientific purposes, particularly radio-astronomy. One of the most important of these windows lies in the frequency band occupied by television channel 37, which is assigned in the United States to commercial broadcasting use. Although no stations are presently using it, a number of applications for licenses are now before the Federal Communications Commission.

The possibility that channel 37 will be taken away and awarded to commercial TV has caused many scientists and engineers, both in this country and abroad, to rise to the defense of maintaining this vital frequency for radio-astronomy. University of Illinois Professors George W. Swenson and George C. McVittie, who head U of I radio-telescope research, agree that if the Federal Communications Commission allocates channel 37 to commercial TV "there is danger that not only will the U of I operation be seriously hampered, but radio-astronomy everywhere in the world will be adversely affected." Professors Swenson and McVittie feel that "television stations on channel 37 will jam signals received by radio telescopes. It would in most cases be impossible to distinguish between waves coming from television and those coming from galaxies billions of miles away."

Although the final decision on the disposition of channel 37 awaits FCC action, those who are interested in the vital partnership between radio-astronomers and other space researchers are hoping that the Commission will maintain the "open window" for science. ◆

A GLASS-WALLED SPACESHIP?

Today two kinds of conveyances face heat problems in the earth's atmosphere: high performance aircraft tunneling through it, and spacecraft on their way into or out of it. Such vehicles require structural materials that can retain their high strength even at extremely elevated temperatures. The refractory (hard to melt) metals (tungsten, tantalum, molybdenum, and niobium) meet this requirement but they all have extremely volatile oxides, which tend to evaporate when used at elevated temperatures in an oxygen atmosphere. This can be overcome by coating such metals with a heat resistant ceramic coating to keep oxygen from reaching the metal.

This is nat a musical instrument, but a radio antenna. It was develaped at the University af Illinais by Prafessar Raj Mittra and M. L. Wahl, graduate research assistant, bath af the Department af Electrical Engineering. They call it a "letter-rack" antenna. It is especially valuable far use an aircraft because af its braad-band and directianal receptian and its flush maunting. The design is a variatian af the lag-periadic antenna, a braad-band design develaped in the U af I Antenna Labaratary.

A program aimed at developing a material capable of protecting tungsten at temperatures of 3,000 to 3,500° F. was recently completed by the University of Illinois Department of Ceramic Engineering for the Aeronautical Systems Division of the U.S. Air Force.

The researchers, Professors C. G. Bergeron, V. J. Tennery, and A. L. Friedberg, decided in preliminary experiments that the non-porous structure of glasses, which are composed primarily of oxides, might provide an excellent basis for a protective coating system. For one thing, glasses, unlike crystalline materials, have no melting point; they soften gradually over a wide temperature range. Therefore if an oxide glass could be developed that would retain a high enough viscosity at the required service temperatures, it could be expected to accommodate stress changes without fracturing and simultaneously prevent oxygen penetration. Another "design" limitation facing the researchers was the necessity of matching the very low coefficient of thermal expansion of tungsten over a wide range of temperatures.

These and numerous other considerations ultimately led to the development of a coating material which, when applied to tungsten laboratory specimens, was able to withstand a temperature of 3,000° F. for more than ten hours. This successful test suggests the possibility of using such coatings on refractory metal components of spacecraft in the future. The coating is composed of a crystalline refractory material (zirconium silicate) and a special glass. At elevated temperatures a slow reaction between the glass and the zirconium silicate results in the formation of tiny crystals of zirconia, while the released silica permits the molten glass to retain a high enough viscosity to protect the refractory metal components. ◆

PEOPLE AND PLACES

Dr. Nathan M. Newmark, Head of the University of Illinois Department of Civil Engineering, has been named to the new U.S. Commerce Technical Advisory Board by Luther H. Hodges, Secretary of Commerce. The fourteen-man board will advise on means of stimulating research and development, provide a liaison between industry and government, and suggest how the Department of Commerce can best meet the needs of industry.

The 1963 A. Epstein Memorial Award for faculty achievement has been presented to Professors J. P. Murtha, Moreland Herrin, and V. J. McDonald of the University of Illinois Department of Civil Engineering.

Professors S. A. Bowhill and G. W. Swenson, Jr., of the University of Illinois Department of Electrical Engineering, were in Rome March 18–22 as members of the United States delegation to the second general assembly for the International Quiet Sun Year of 1964 and 1965.

University of Illinois Professors L. P. Kadanoff and M. V. Klein, physicists, and S. G. Smith, chemist, have been notified that they are among 66 American and Canadian scientists receiving fellowships totaling $1 million from the Alfred P. Sloan Foundation.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 4, NO. 6, JUNE 1963

U OF I SOLUTIONS FOR AEROSPACE PROBLEMS

Life can be complicated for an aerospace engineer. In designing structural components for flight vehicles, he must always consider strength, lightness, flexibility, and temperature dependence, four design parameters that are often diametrically opposed — the strongest material is not the lightest, the lightest may be too flexible, and so on. Yet they are all important considerations in air- and spacecraft design, an exacting science that has stimulated a tremendous amount of fundamental research in the United States in the last few years. A great deal of this research has been and is being done in the Department of Aeronautical and Astronautical Engineering (AAE) at the University of Illinois.

During the past twelve years this research, under the general supervision of Dr. H. H. Hilton, has been on problems associated with thermal stresses, creep (temperature-induced deformations), creep buckling (creep-induced structural failure), aeroinelastic phenomena (flutter in the presence of creep), the prediction of failure based on probability theory, and the structural analysis of solid fuel rocket propellants.

These studies, more fully described in past issues of *Outlook* (e.g., January, March, and April 1962), are all related to the two primary concerns of the aerospace engineer: high temperatures in structural members, and the extreme flexibility of lifting and control surfaces. The flexibility of various components, which results from the all-important consideration of weight saving, is always a problem for the designer, who must calculate how flexible and light a part can be and still have adequate strength to function. Dr. Hilton has devised a theory of aeroinelasticity which allows the engineer to predict the possibility of flexibility-induced trouble spots such as flutter in a creeping wing.

High temperatures are responsible for many kinds of structural component failures in high speed flight vehicles. One of the most significant results of the AAE studies in this area has been the formulation of the theory of nonhomogeneous viscoelasticity. This theory, which allows savings in design time and money, permits the solution of complex viscoelastic thermal stress problems in terms of elastic solutions, which are much easier to work with. Other outstanding contributions from this work have included the studies in creep buckling which make it possible to compute usable lifetimes of flight vehicles. Dr. Hilton and his group have also devised analytical means for predicting stresses and deformations in solid rocket fuels, design parameters that are extremely important in rockets such as Polaris and Minuteman.

The average aerospace engineer's life is not a simple one, but it would be a good deal more complicated today if it were not for some of the University of Illinois work that has been adopted by the aerospace industries. ◆

HOW TO GO TO MARS AND BACK

The blueprint for an expedition to explore Mars, published a decade ago by the University of Illinois Press, has just been reissued as one of the first volumes of its new Illini Book series of paperbacks.

The Mars Project by Wernher von Braun presents, in sober, scientific language, calculations for an expedition of 70 men to go to Mars, where 50 of the party would explore for 400 days. Two years and 239 days would elapse between departure from and return to Earth.

Von Braun made calculations for the project in 1948. Several publishers turned the book down before the University of Illinois Press published it in 1953. The first printing was completely sold out. When the University Press initiated its new paperback series late in 1962, *The Mars Project* was reprinted with a new foreword by von Braun.

Von Braun was a contributor to a still earlier University of Illinois Press book, *Space Medicine,* published in 1951. It presents papers given at a March 3, 1950, symposium held on the University's Medical Center campus in Chicago. Copies of both of these pioneering volumes are available from the University of Illinois Press. ◆

An engineer from the Department of Electrical Engineering's Gaseous Electronics Laboratory makes final adjustments on the experimental apparatus for studying Rayleigh scattering of laser light from gases.

WHY IS THE SKY BLUE?

The sky's color, as you perhaps know, is caused by the fact that short wave lengths of light (blue) are scattered more than the long wave lengths (red) as they strike molecules of air in the earth's atmosphere. Recently three researchers in the University of Illinois Department of Electrical Engineering have observed "Rayleigh scattering" in a "pure" form not heretofore seen. Rayleigh scattering is the scattering of light from particles which are very small compared to the wave length of light. In such scattering, shorter wave lengths are scattered more than long wave lengths — and we are back to the blue sky. Dr. M. Yokoyama, L. P. Slama, and T. V. George have made these observations by utilizing a specially built ruby laser (see *Outlook,* Feb. 1961) that prevents the random scattering off the walls of the apparatus found in earlier experiments using less coherent sources of light.

Specifically concerned with the verification of light scattering by gas molecules, the researchers in the E. E. Department's Gaseous Electronics Laboratory are studying scattering of light from particles which measure less than one-hundredth of a millionth of an inch. In these experiments by the U of I research team, light from the laser was "bombarded" with gas molecules in a specially designed vacuum system. With this system, data was taken which was comparatively free of the troublesome spurious scattering which always heretofore has been a stumbling block to observations of "Rayleigh scattering."

Scientists have for years had an explanation for the blueness of the sky, but there are still many mysteries about the behavior of light. Sponsored by Air Force and Army Signal Corps contracts, the U of I scattering experiments are of interest not only because they help to confirm existing hypotheses concerning various aspects of color, but because they will help man to a better understanding of the basic behavior of light itself. ◆

CRACK CONTROL IN REINFORCED CONCRETE

Most existing concrete structures have cracks in them. Sometimes these cracks extend to the reinforcing material, exposing it to the elements so that it corrodes. Although this is often not a cause for great alarm, it is not impossible that by this process the structure could become weakened, or even collapse. Crack control thus plays an important part in reinforced concrete design.

Professor Clyde E. Kesler and his staff in the University of Illinois Department of Theoretical and Applied Mechanics recently conducted an investigation into this problem. The study dealt with the crack control characteristics of a deformed wire grid reinforcement material. Two different types of experiments were performed in determining these characteristics — bond behavior experiments and slab tests.

Because a reinforcing material that bonds well to the concrete will result in smaller crack widths, the researchers reached the conclusion that bond behavior is directly related to crack control. Testing machines were used to pull the reinforcement material out of concrete cylinders, and the bond strengths for various types of reinforcements determined. Deformed wire displayed significantly greater bond strength than plain wire.

Slab tests were also made by supporting 5″ x 24″ x 76″ concrete slabs on a 72″ span and placing loads 12″ from either support. Some of the slabs were reinforced with the deformed wire and others with plain wire. Results showed the crack widths in slabs reinforced with the deformed fabric were smaller. In some cases, crack widths in deformed wire slabs were over twice as small as widths in similar plain wire slabs.

These preliminary experiments point out the excellent crack control qualities of a deformed wire reinforcement material. Current studies are aimed at finding the reasons for crack formation, finding how large cracks can be before they are considered critical, and refining the various methods of crack control. ◆

COMBATING TEMPERATURES IN OUTER SPACE

In space, as on the ground, there is sometimes too much heat and sometimes too little. For this reason the engineer-spacecraft designer has to know a great deal about heat and how it is conducted through different kinds of materials. When it flows from one object to another, a measurable temperature drop occurs where the objects touch. This "thermal contact resistance" is attributed to imperfect contact between the touching members. In a vacuum environment this resistance is often quite large compared to the overall thermal resistance of the contacting members, so an understanding of its behavior is important in spacecraft design. A study of thermal contact resistance, sponsored by NASA, is being conducted in the University of Illinois Mechanical and Industrial Engineering Department.

This program, conducted by Professor B. T. Chao and Mr. Arthur M. Clausing, is not only designed to achieve an understanding of the physical mechanism governing such resistance, but to develop a means by which it can be predicted. Some of the more important variables being studied are the elastic and plastic behavior of the contacting members under load; the geometry of the contact surface, both at the macroscopic and microscopic levels; the distribution of contact stress; and the thermal conductivity and coefficient of thermal expansion of the materials in contact.

When man moves into space he will have to take an earth environment with him in order to survive, but he will also have to exercise careful planning to protect it from the surrounding environment of space. A successful spacecraft or space station is going to depend heavily on the engineer's ability to design the outside of the vehicle to protect the artificial environment and the human life inside. A good understanding of heat transfer will be an important ingredient in that ability. ◆

WELDING SYMPOSIUM PROCEEDINGS

The Special Symposium on the Behavior of Welded Structures brought eight internationally known engineers from Belgium, England, France, Germany, and Sweden to speak before a distinguished group on the University of Illinois campus. Their talks described the welding research being done in their countries and for the commissions of the International Institute of Welding.

Engineering Experiment Station Circular No. 74, *Proceedings of the Special Symposium on the Behavior of Welded Structures,* is now available for distribution from the Engineering Publications Office, University of Illinois, Urbana, Illinois. The 223-page publication contains the welcoming remarks of Dr. N. M. Newmark and the eight talks (with illustrations) of the guest speakers. It is $1.00 per copy. ◆

AN AIR CONDITIONING GUIDE

With really hot weather almost upon us, many readers may be interested in Bulletin No. 465, *Comparative Performance of Year-Around Systems Used in Air Conditioning Research Residence No. 2.* This 80-page booklet by J. R. Wright, D. R. Bahnfleth, and E. J. Brown, all former members of the University of Illinois Department of Mechanical Engineering, reports the results of air conditioning investigations conducted to study the effect of type and location of supply outlets and to determine the operating procedures for obtaining the best comfort conditions with each outlet type. Three types of supply outlets are discussed: perimeter floor diffusers, ceiling diffusers, and floor registers located near inside walls. The performances of these three systems for both heating and cooling are compared with a system investigated previously (high sidewall registers).

Bulletin 465 is available for $1.75 from Engineering Publications, University of Illinois, Urbana, Illinois. ◆

ORDER FORM — send with remittance to Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois

- ☐ Bull. 465, *Comparative Performance of Year-Around Systems Used in Air Conditioning Research Residence No. 2,* J. R. Wright, D. R. Bahnfleth, and E. J. Brown. *One dollar and seventy-five cents.*
- ☐ Circular 74, *Proceedings of the Special Symposium on the Behavior of Welded Structures. One dollar.*
- ☐ Circular 75, *Water Distribution Systems,* the Proceedings of the Fourth Sanitary Engineering Conference. *Two dollars.*
- ☐ Circular 76, *Illinois Highway and Agricultural Drainage Laws,* C. J. W. Drablos and B. A. Jones, Jr. *One dollar and fifty cents.*
- ☐ Tech. Report 4, *On Elastic Wave Propagation in Crystals with Applications to Calcite and Quartz,* A. J. de Witte. *One dollar.*
- ☐ Reprint 64, *Progress Reports of Investigations of Railroad Rails,* R. E. Cramer. *Fifty cents.*
- ☐ *A Summary of Engineering Research, 1962–63. No charge.*
- ☐ *Engineering Calendar,* a weekly calendar of seminars and discussions at the University of Illinois. *No charge.*

A CRYSTAL-PHYSICS REPORT

Of special interest to physicists and petrophysicists is a new technical report ready for distribution by the University of Illinois Engineering Experiment Station. Technical Report No. 4, *Elastic Wave Propagation in Crystals with Applications to Calcite and Quartz,* by Professor A. J. de Witte, is a 50-page report dealing with the basic facts on propagation of elastic wave-fronts in anisotropic solids. The new contributions of this Technical Report consist of mathematical characterizations of the various velocity surfaces and figures showing these surfaces as obtained by a computer from the known elastic constants of calcite and quartz.

Technical Report No. 4 is available from the Engineering Publications Office, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois, at $1.00 per copy. ◆

A COMPILATION OF ILLINOIS DRAINAGE LAWS

The basic points of Illinois drainage law and their application to highway and agricultural drainage have never before been assembled into a single source of material. Because of the enormous body of laws related to drainage and the lack of a comprehensive guide, there has been much misunderstanding and confusion on the part of farmers and engineers on the ramifications of these laws and court rulings. Now a compilation and analysis of such laws has been published by the University of Illinois Engineering Experiment Station.

Circular No. 76, *Illinois Highway and Agricultural Drainage Laws,* by C. J. W. Drablos and B. A. Jones, Jr., of the Department of Agricultural Engineering, contains information on the history of Illinois drainage laws, natural drainage, statutory drainage, bridges and culverts, sewage and pollution, and legal remedies. It contains a glossary of terms, a long list of references and court cases cited in the text, and an extensive index. Circular 76 is available for $1.50 per copy from the Engineering Publications Office, University of Illinois, Urbana. ◆

PEOPLE AND PLACES

Ellis Danner, Professor of Civil Engineering at the University of Illinois and director of the Illinois Cooperative Highway Research Program, will go to Europe this summer to study highway construction in foreign countries under a $4,000 travel award established by the General Paving Foundation of Champaign, Illinois.

Professor Heinz von Foerster, head of the Biological Computer Group in the University of Illinois Department of Electrical Engineering, has been awarded a Guggenheim Fellowship for "studies of molecular mechanisms in biological memory."

Harry G. Drickamer, Professor of Chemical Engineering, has been named to full membership in the University of Illinois Center for Advanced Study beginning next September.

Professor M. A. Sozen of the University of Illinois Department of Civil Engineering presented a paper at the Symposium on Reinforced Concrete Slabs in April at Wiesbaden, Germany. He visited institutions in Denmark, Sweden, Germany, France, and the United Kingdom while on the trip.

Professor Lloyd D. Fosdick, University of Illinois Department of Physics, has been awarded a Guggenheim Fellowship for "studies of probabilistic methods for solving problems in statistical physics using high-speed computers."

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ENGINEERING OUTLOOK

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 4, NO. 7, SEPTEMBER 1963

1962-63: A SUMMARY OF A BIG YEAR

The recent academic year was an important one for the College of Engineering and consequently, we trust, for the profession of engineering.

EDUCATIONAL PROGRAMS

Engineers are the most important product of the College of Engineering, and educating them is the College's most important project. Continuous striving over the years for high educational standards has not resulted in low numbers in the undergraduate enrollment, graduate enrollment, or degrees-granted columns. Although comparative figures for 1962-63 are not yet available, the record should compare well with the previous year, when the University of Illinois, according to the U.S. Office of Education, granted more engineering degrees than any other institution in the United States: 669 baccalaureate degrees, 327 Master of Science degrees, and 94 doctorates. In addition, 53 baccalaureate degrees, 56 master's, and 27 doctorates were awarded in physics.

One significant happening of the year was that a new program in the humanities and social sciences was established, requiring every engineering student to take at least eighteen semester hours in these fields.

The College's Honors Program was quite active with a total of 135 students participating, and several new ideas were implemented, such as a program in Civil Engineering allowing carefully selected honors students to receive tutorial teaching from the staff during their senior year. Student placement activities were vigorous: in the fall of 1962, a total of 314 companies visited the campus to interview engineering graduates, and 385 of them visited during the spring of 1963. In addition, the Engineering Placement Office published and offered to industry a semester report, an annual report, and a five-year report on employment of our graduates.

RESEARCH PROGRAMS

The year witnessed the College's involvement in 439 separate research projects, 308 of which were sponsored by 32 private companies, 11 industrial organizations, 7 private foundations, and 36 federal and state agencies. The remaining 131 projects were supported by University funds. Research income for the year, the highest in history, was 12¼ million dollars. The University's nuclear reactor, the only university-operated reactor licensed to "pulse" to power levels above 250 million watts, was given authorization by the AEC to pulse to even higher levels. The Materials Research Laboratory, made up of five participating departments of the College, completed its first year of operation with 22 research projects in progress and plans completed for its new headquarters. PLATO, the computer-controlled automatic teaching system of the Coordinated Science Laboratory, was given multi-student capabilities during the year.

The College was especially active in various types of participation in the nation's space program during the year. A whole new research program in aeronomy was begun, and plans were laid for the University's contribution to the NASA rocket program to study properties of the ionosphere during the coming International Quiet Sun Year. During the recent eclipse, the University, in cooperation with Stanford University, carried out a major study of the ionosphere from stations in Alaska, Canada, Illinois, and Washington. Further work was completed on plans to cooperate with NASA in placing one of the Coordinated Science Laboratory's electric vacuum gyroscopes in orbit to check Einstein's theory of relativity by measuring gyro drift rate.

PUBLIC SERVICE PROGRAMS

In addition to the usual large number of summer science training institutes, short courses, and guidance activities, the College's public service programs were increased in 1962-63, partly because of the University's expanded efforts to interact with industry. During the year, the Board of Trustees approved the establishment of the Midwest Electronics Research Center as an administrative mechanism to facilitate increased cooperation with industries in electronics and related areas of solid state physics, and the Production Engineering Educational

and Research Center as an interdisciplinary program designed to promote new interaction with the machine tool industry.

The year marked the tenth anniversary of one of the University's biggest international public service efforts, the program of cooperation with and aid to the Indian Institute of Technology at Kharagpur, India.

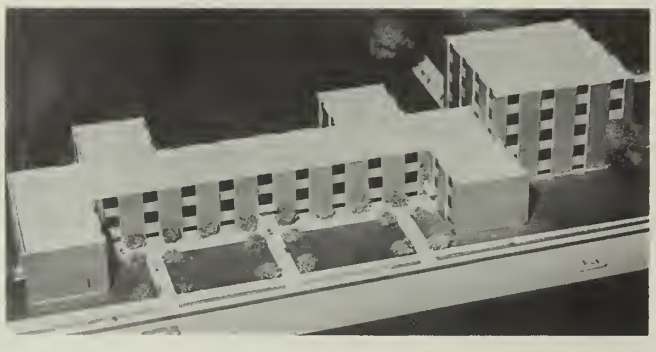
NEW FACILITIES

In addition to the growth seen during the year in various programs of education, research, and public service, the College campus itself was growing. The year saw the completion of the new Physics Building, the announcement of plans for a new Civil Engineering Building, and the first showing of the proposed appearance of the Materials Research Laboratory. The Board of Trustees approved plans for the construction of the new Coordinated Science Laboratory. The construction of a new wing on the Digital Computer Laboratory to house integrated circuitry facilities was started, the first tests were run on ILLIAC II in the same building, and an IBM 7094 computer and auxiliary equipment were purchased and put into operation. One other sizable research facility had its birth certificate signed and stamped during the year: the University of Illinois radio telescope was dedicated in a formal ceremony in October, 1962.

A GROWING COLLEGE WITH GROWING CHALLENGES

A glance back over 1962-63 demonstrates that the College of Engineering is increasing in size, scope, and breadth of interests, and the challenges it is facing are also growing. In addition to its responsibilities in engineering education and research, the College is aware of its increasing role in the economic development of Illinois, the midwest, and the nation, and it is taking steps to respond positively through new programs of industry interaction, public service, and cooperative research.

This model shows the oppearance of the new Coordinated Science Loboratory building now being built an the corner of Springfield ond Goodwin avenues. One third of the totol structure will be completed next year.



This sketch shows the finished appeoronce of the Moterials Reseorch Loboratory building thot is now being built on the University of Illinois compus. The building on the right that is connected to it is the new Physics Building.

THE MIDWEST ELECTRONICS RESEARCH CENTER

Back in the golden age of the Greeks the principle of reaction turbines was demonstrated; but hundreds of years passed before the modern steam turbine was developed. In 1948, Dr. John Bardeen and two colleagues discovered the transistor; within four years it was the basis of a multi-million-dollar industry. How narrow will the gap between discovery and application be tomorrow?

Every industrial organization approaches this problem in its own way — but it is generally recognized that organizational leadership and prosperity in a rapidly evolving technology depend on developing closer relationships between the discovery of new knowledge and the means of applying it.

An aid to industries being squeezed in the narrowing gap between discovery and application in electronics has been conceived by Dr. Bardeen, Professor of Electrical Engineering and of Physics at the University of Illinois. This modern approach to the problem, the Midwest Electronics Research Center, is designed to assist electronics firms in handling the complex research required for military and space problems, new areas of civilian technology, and new product development.

The Midwest Electronics Research Center is a flexible organization capable of quickly devising new procedures to solve unusual problems, but it contains a number of established programs calculated to aid electronic industries in keeping up with (or ahead of) their fields. These programs include:

- Applications Forums and Seminars
- Cooperative Industry–University Research Programs
- Consultantship Arrangements
- Continuing Educational and Professional Development Programs
- Interpretive Literature Publication and Distribution Activities
- Joint Industry-wide Laboratories

MERC also sponsors a Visiting Industrial Associates Program, which permits technical personnel from industry to participate in ongoing research programs on the College of Engineering campus at Urbana. Participation in MERC activities by an industry man carries with it a corporate membership arrangement that facilitates the use of existing mechanisms and the establishment of new means of cooperative efforts.

The Center is a catalyst in the creative idea development process at all levels. It provides direct assistance to industrial firms as they seek to increase their own research potential, and it helps stimulate basic research by University staff members on problems of interest to industry. In this way it is a mutually beneficial program: it encourages a combination of the rapid response time of industry with the breadth and depth of the University's talents and facilities. This wide scope of University activities is clearly seen in such diverse interdisciplinary research programs as the Coordinated Science and Materials Research Laboratories, as well as the multi-faceted research activities of the Electrical Engineering and Physics departments. The Center, as a coordinating agency, establishes the tie between the idea, the pilot model, and the product.

STRUCTURAL MECHANICS CLASSROOM MODELS

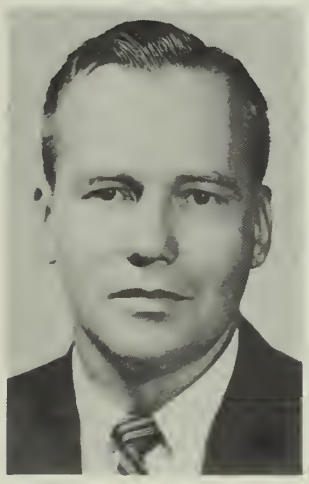
After discussing the types of demonstrations that can effectively be used to clarify various aspects of structural analysis and response, Engineering Experiment Station Circular No. 78, published in June, gives some equipment designs suitable for this purpose. This equipment includes a series of elastic theory, plastic theory, and photo-elastic models that can be constructed quickly to suit individual requirements. The designs are suitable for manufacture in the average small workshop.

The 84-page circular, *Demonstration Models for Teaching Structural Mechanics,* by W. G. Godden, is available for $2.00 per copy from the Engineering Publications Office, University of Illinois, Urbana.

A TURBULENCE PRIMER

Circular No. 79, just published by the Engineering Experiment Station, is an introduction to turbulence for engineers and researchers in technical fields where turbulent motions are encountered. Many of these people have had little contact with advanced fluid mechanics and little opportunity to delve into the mysteries of turbulence. And yet they need some understanding of our modern scientific concepts of the nature of turbulence as well as an introduction to the terminology conventionally employed in this field. Circular 79, *A Turbulence Primer,* is designed to fulfill these needs. The 28-page circular, written by Professor James M. Robertson of the Theoretical and Applied Mechanics Department, is available for $1.00 per copy from the Engineering Publications Office, University of Illinois, Urbana.

ACADEMIC COORDINATOR FOR THE COLLEGE OF ENGINEERING



Jimmy W. Seyler has joined the College of Engineering administrative staff on a joint appointment as Academic Coordinator of Extension in Engineering between the Division of University Extension and the College of Engineering.

For the past four years Professor Seyler has divided his time between the American Society for Engineering Education, where he was Assistant Secretary, the University, where he taught courses in the Department of Civil Engineering, and the Division of University Extension, where he served as academic coordinator. Previous to that he spent five years teaching civil engineering courses at the University, a period of time in the U.S. Navy, several years doing graduate work at the U of I, and five years working as a professional engineer. He now coordinates the presentation of all programs of engineering instruction (including graduate courses) offered by the University at locations other than the Urbana campus, credit and non-credit extramural engineering courses, conferences and short courses offered at Urbana or in other Illinois communities, and engineering instructional programs developed in University–industrial relationships.

ENGINEERING DEPARTMENTAL REPORTS AND THESES, 1962

This new publication contains bibliographic data and abstracts of research reports published by departments in the University of Illinois College of Engineering during the 1961-62 fiscal year. The bibliography provides information about papers written by the research staff which may not be available except as departmental publications. Titles, authors, and advisors are presented for master's theses and doctoral dissertations.

Engineering Departmental Reports and Theses, 1962, Engineering Experiment Station Circular 77, is available free of charge from the Engineering Publications Office, University of Illinois, Urbana.

THE FIRST FIVE YEARS OF THE ENGINEER

In 1958, the University of Illinois College of Engineering graduated 733 engineers. In a recent survey by the Engineering Placement Office to discover what had happened to these people over the last five years, some interesting facts turned up: 438 of them responded to the survey; the average starting salary in 1958 for these men was $486.83 a month; 409 are gainfully employed today; their average monthly salary is $809.48, a gain of 66.28 percent over the five-year period. But — 83 of them had returned to school from one to four years to complete an advanced degree, and 99 of them are working on advanced degrees now. Another 103 of them spent from a few months to four years of the five-year period in the armed services.

It is obvious that the graduates who have spent all or most of the five years working have done very well; what of the ones who took some time off for advanced college work? Of the 409 engineers now working, those with no advanced degree have an average monthly salary of $794.64. In spite of the time they had to be away from their jobs over the five-year period, those with master's degrees are averaging $846.84; and those with doctorates are averaging $1032.71 a month. It appears that the money lost in not being gainfully employed while getting advanced schooling is more than recovered in the engineer's ability to command a higher salary if he holds advanced degrees.

PEOPLE AND PLACES

Professor W. W. Hay, University of Illinois Department of Civil Engineering, has been named by Dr. Frederick Seitz, President, National Academy of Sciences, to the academy's new committee on science and technology in the railroad industry.

Dr. M. E. Van Valkenburg, Associate Director of the University of Illinois Coordinated Science Laboratory and Professor of Electrical Engineering, won the 1963 George Westinghouse Award of the American Society for Engineering Education, given annually to "engineering teachers of outstanding ability to recognize and encourage their contributions to the improvement of teaching methods for engineering students."

Dr. T. J. Hanratty, University of Illinois Department of Chemistry and Chemical Engineering, has been given the 1963 Curtis W. McGraw Research Award of ASEE, which is "to recognize outstanding early achievements by engineering college research workers and to encourage continuance of such productivity in the future."

Professor S. Konzo, Associate Head of the Department of Mechanical and Industrial Engineering, was given a distinguished service award by the American Society of Heating, Refrigerating, and Air Conditioning Engineers in June, 1963.

Dr. A. L. Friedberg is the new Head of the University of Illinois Department of Ceramic Engineering. He succeeds **Dr. A. I. Andrews,** who has retired.

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LEONARD COBURN
119 C.E.H.
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 4, NO. 8, OCTOBER 1963

APPLICATIONS FORUM ON ANTENNA RESEARCH

One of the central functions of the Midwest Electronics Research Center is to sponsor short courses and forums on selected topics of electronics and solid state physics for industry researchers. Next January 27–30 MERC will sponsor and conduct an Applications Forum on Antenna Research on the University of Illinois campus. The four-day conference is intended to bring graduate engineers with current interests in antenna research or production up to date on the rapidly developing antenna and wave propagation technology.

The conference, which will be directed by Professor Paul Mayes of the Department of Electrical Engineering, will be divided into four sections: frequency-independent antennas, antennas in anisotropic and conducting media, aperiodic arrays, and data processing antenna systems and partial coherence. For applications, reservation forms, or further information about the January Applications Forum on Antenna Research, write to:

Midwest Electronics Research Center
Electrical Engineering Building
University of Illinois, Urbana

HOME HEATING AND COOLING WITH ONE SYSTEM

The use of valance units for both heating and cooling of a home is described in Engineering Experiment Station Bulletin No. 466, *Hydronic Heating and Cooling with Valance Units,* by Warren S. Harris and Robert R. Laschober. The units, which were designed to be installed along outside walls near the ceiling, carried chilled water in the summer and heated water in the winter. The tests were conducted in the I=B=R Hydronic Research House at the University of Illinois.

The 56-page bulletin describes the equipment used, test conditions and procedures, valance outputs, loads and equipment performance, and comfort conditions. It is available for $1.00 per copy from the Engineering Publications Office, University of Illinois, Urbana. ◆

BILLION WATT REACTOR PULSES LICENSED

Two years ago the University of Illinois' TRIGA nuclear reactor was licensed by the AEC to "pulse" up to a power level of 250 million watts. This gave the reactor some of the research capabilities of a much larger and more expensive installation, and the University of Illinois was (and still is) the only university licensed by the AEC to do this. Last September the U of I nuclear engineering program announced that authorization had been received from AEC to pulse up to one billion watts.

Pulsing is not achieved by suddenly adding more fuel to the reactor, but rather by removing some of the "poison" or neutron-absorbing material from the fuel already present. This is done by literally "blowing" a control rod out of the reactor core with compressed air. A pulse is a rapid, brief increase in the power level of an operating reactor. A "one dollar" change in reactivity is the amount of fuel that has to be added to a reactor operating at a steady power level to permit a chain reaction just with the "prompt" neutrons. For the last two years the University has been pulsing up to twice this amount, or "two dollars" worth. The recent licensing from AEC allows "three dollar" pulses.

Such a pulse will last for less than one-tenth of a second before the machine's self-limiting features automatically pull it back to a steady output of a few hundred thousand watts. The increase extends the range of research which can be carried on and reduces by three-fifths the time previously needed for many projects.

The College of Engineering's nuclear engineering program offers only graduate degrees at the master's and doctoral levels. The reactor is used not only for teaching but as a research tool, both as a source of radiation for departments from all parts of the campus and as a source of experimental information for studies about reactor design and operation. The new higher pulsing capability will make it a far more useful facility for all of these programs. ◆

A new type of vocuum gouge has been invented by W. C. Schuemonn of the University af Illinais Coordinoted Science Laboratory. It is copoble of measuring pressures at leost ane hundred times lower thon is possible with present widely used ianization gouges. The University af Illinois Faundation has opplied for a patent, ond severol commercial firms hove expressed interest in monufacturing the gauge.

A DECADE OF ACHIEVEMENT IN INDIA

This year marks the tenth anniversary of a new era in engineering education in India. In 1953, the University of Illinois became involved in discussions about an assistance program for the Indian Institute of Technology at Kharagpur, West Bengal. IIT Kharagpur, founded in 1952, was the first engineering college established by the Indian National Government. Through the United Nations-sponsored negotiations an assistance program was established with the U.S. International Cooperation Administration, and in 1954 the first contingent of University of Illinois professors arrived at Kharagpur and went to work.

IIT Kharagpur has become the outstanding engineering school in India. The assistance of the University of Illinois professors under contracts of the ICA and its successor, the Agency for International Development, has played a significant part in this success. Over the years the University of Illinois has served as purchasing agent for 1½ million dollars worth of equipment purchased by the U.S. government agencies. More than a score of University of Illinois professors have been at the Institute, both as full-time members of the staff and as visitors making executive inspections and giving lectures and seminars. Hundreds of Indian students and faculty members have been brought to America to study in their respective fields of engineering and to learn American methods of teaching before returning to India. Approximately 80 percent of the students who came attended the University of Illinois.

Today IIT Kharagpur is a progressive engineering school with 1,580 undergraduate students and 287 graduate students. The school is strong in research and graduate training. Last year it granted 20 Ph.D.'s, 1 D.Sc., and 165 master's degrees, in addition to nearly 400 baccalaureate degrees. Of the 287 students doing graduate work, 69 were Research Scholars and Fellows, 41 were teacher trainees, and the remaining 177 were postgraduate students. The success of the Institute has caused four other similar institutions to be started in India, none of which are more than four years old. The Institute at Kharagpur has served as a model for the other schools.

In addition to its large graduate program, the Institute is well known for its outstanding research programs and its use of the American system of teaching and evaluating student accomplishments. Examples of current research projects being directed by University of Illinois professors are the development of a smokeless furnace for high-ash-content India coal, a smokeless locomotive engine, a computer program, and a central instrumentation services center as a model for all India. The American system of teaching and grading, which is very much different from the Indian system, includes giving exams every term and grading on the letter-grade basis. The other Institutes of Technology in the country have copied this system. The Kharagpur IIT is also known throughout India for its excellent agricultural engineering program, which was developed under the direction of U of I Professor Ralph C. Hay.

Professor Hay's work is unique because he organized the first agricultural engineering department in India. He designed the building, organized a staff of teachers, and trained them for their work. He made a great contribution to the establishment of an agricultural engineering program that is considered second to none in India, primarily because it was specifically designed to study and solve Indian agricultural problems. IIT Kharagpur is presently the only educational institution in India offering a master's degree in this field.

The University of Illinois has long been active in international educational programs. According to the Institute of International Education in New York City, Illinois ranks third among the states with the most foreign students, the University of Illinois is third among universities with the highest foreign student enrollment, and the University ranks ninth among U.S. institutions with the largest number of faculty members abroad. The work at IIT Kharagpur represents the largest single international effort the University has made to date.

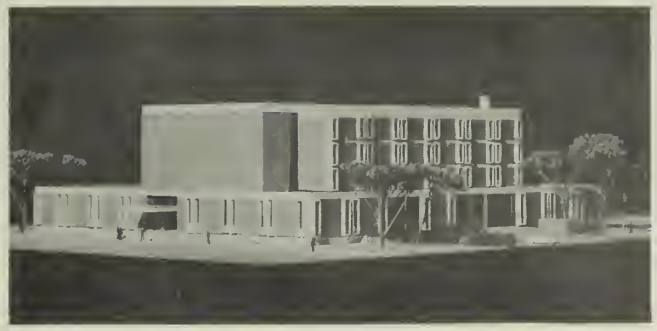
During the past year, ten University of Illinois faculty members have been at Kharagpur. These men are continuing to build on the achievements of the last ten years — a decade that has seen the foundation laid for modern engineering education in India. ◆

THE PRODUCTION ENGINEERING EDUCATIONAL AND RESEARCH CENTER

A machinist used to finish his day with a basket of chips and a teacup full of broken or worn out cutting tools; since the introduction of modern superhard alloys, he sometimes gets a basket full of tools and a teacup full of chips. This is only one of the many problems that are costing the machine tool industries and their consumers many billions of dollars each year. Such problems will be the major interests of a new educational and research center established on the University of Illinois campus in 1963.

PEERC, or Production Engineering Educational and Research Center, is an interdisciplinary effort sponsored and organized through the participation of the Departments of Mechanical and Industrial Engineering; Electrical Engineering; Mining, Metallurgy, and Petroleum Engineering; General Engineering; Theoretical and Applied Mechanics; the Coordinated Science Laboratory; the Department of Economics of the College of Commerce; and the Engineering Experiment Station.

Some of the many aspects of production engineering with which PEERC will concern itself are machine tool engineering, metal processing, mechanization, automation and control engineering, tool and manufacturing engineering, and processing systems engineering. The activities of the Center will include the development of a graduate educational program, the strengthening of current research areas, the opening of new research areas, the evaluation of foreign developments, the development of an inclusive library, and the dissemination of its findings through short courses and symposia, lectures, conferences, and interpretive publications. ◆



This model shows the appearance of the first unit of a much larger Civil Engineering Building to be built at the University of Illinois. The central feature of the building will be a three-story laboratory for structural research. It is scheduled for completion in Sept., 1965.

TECHNOLOGY CURRICULUM GUIDES FOR JUNIOR COLLEGES

One subject of long interest to the University of Illinois has been the national shortage of engineering technicians. Much work on this problem has been done in the past, primarily through the College of Engineering's Advisory Committee on Technical Institute Curriculum. This committee, chaired by Professor J. S. Dobrovolny, issued last June the first in a series of curriculum guides in engineering technology for junior colleges.

The 60-page booklet, entitled *Machine Design Technology,* was prepared jointly by the Illinois State Board of Vocational Education and the University of Illinois. It is a guide for a two-year training program in machine design technology. It covers general ability requirements for students interested in the course, requirements for teachers, and a series of course outlines. The committee is presently considering the production of curriculum guides in electronics, chemical, and production technology.

ORDER FORM — send with remittance to Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois

- ☐ Bull. 466, *Hydronic Heating and Cooling with Valance Units,* W. S. Harris and R. R. Laschober. *One dollar.*
- ☐ Circ. 77, *Engineering Departmental Reports and Theses, 1962. No charge.*
- ☐ Circ. 78, *Demonstration Models for Teaching Structural Mechanics,* W. G. Godden. *Two dollars.*
- ☐ Circ. 79, *A Turbulence Primer,* J. M. Robertson. *One dollar.*
- ☐ *Engineering Calendar,* a weekly calendar of seminars and discussions at the University of Illinois. *No charge.*
- ☐ *Careers in Engineering,* a guidance booklet for high school students. *No charge.*
- ☐ *Humanities and Social Sciences,* a guidance booklet that lists new humanities and social sciences requirements for students in the College of Engineering. *No charge.*

Although only a limited number of copies of the booklet are available, single copies may be obtained by writing to Professor J. S. Dobrovolny, Head, General Engineering Department, University of Illinois, Urbana. ◆

TO INSURE SOLID RESULTS

Pick up any newspaper today, and you will probably be able to find an article concerning a rocket fired somewhere in this country. The article might mention the type of fuel used — either solid or liquid — to power the rocket.

Early rockets were all powered by a liquid propellent; the fuels ranged from kerosene to liquid oxygen. These materials perform well, but they are expensive, involve extremely complicated systems, and require hours of prelaunch time for fueling.

In recent years extensive investigations have been carried out concerning the solid fuel rocket. Solid fuel is cheaper than liquid propellent, and since the solid fuel is cast — like plaster — in the rocket casing, these rockets are ready to be fired as soon as they are moved to the launching pad. Unfortunately the solid propellent also has its problems. The major one is the cracks and displacements occurring in the fuel mass, which can cause the rocket to malfunction. These imperfections can be caused by temperature changes, shrinkage of the propellent, and internal pressure upon firing. Also because of the height of the rockets, they are usually stored horizontally; even this act can cause cracks to form in the fuel mixture.

In June, 1961, the Rohm and Haas Company, Redstone Arsenal Research Division, contracted the University of Illinois Department of Theoretical and Applied Mechanics to investigate the solid fuel problems in detail. Howard Wilson directed the study, and although he left the U of I in 1962, he continued to work on the project and enlisted the aid of Charles C. Fretwell, also of the T & AM Department, to develop a computer program which would obtain numerical results. Through the use of the University computer facilities, an analysis of the stresses and displacements in the fuel mass was completed. These results have given the aerospace industry extremely useful knowledge as to the behavior of solid fuel masses and the limits of temperature change, shrinkage, and pressure it can withstand.

Of course in the solid fuel system, as in any new complex scientific achievement, certain minor "bugs" remain. However, for rockets ready to fire at a moment's notice, the future of solid propellents looks bright indeed. ◆

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 4, NO. 9, NOVEMBER 1963

RESEARCH DOLLARS 1961–62

The University of Illinois College of Engineering is third in the nation in the size of its research program. This information is given in the 11th edition of the *Engineering College Research Review* published by the Engineering College Research Council of the American Society for Engineering Education. The current issue presents figures for the 1961–62 academic year.

Research expenditures reported in colleges of engineering — excluding research foundations or similar separate organizations — totaled $17,207,000 at Michigan, $13,100,000 at MIT, and $11,462,000 at Illinois.

Increasing sums of money for engineering research are being made available each year. At the University of Illinois, for example, the total for 1962–63 rose to $12,262,000, which was approximately one-half of the entire research budget of the University of Illinois. More than ninety per cent of the engineering research funds come from government or industry sources. ◆

A COMMON MARKET APPROACH TO GRADUATE EDUCATION

The University of Illinois is cooperating with ten other universities in breathing life into one of the most exciting graduate study developments in the history of higher education. The Committee on Institutional Cooperation (CIC) represents the Big Ten universities and the University of Chicago in efforts to establish interinstitutional cooperative research and educational programs. The latest work of this Committee has resulted in the "traveling scholar" program — a plan to encourage graduate students to move freely from one institution to another while registered at their home universities.

The common market approach to graduate education will make it possible for a graduate student enrolled in any of the CIC institutions to attend any of the others for one semester or two quarters. This will give him the opportunity to take advantage of the best courses in his specialty, the most outstanding facilities, and the most highly qualified instructors at any of the member universities. It will allow the CIC member institutions to avoid the duplication of efforts and expenditures while increasing their own special strengths in particular areas of interest to them.

Since its establishment in 1958 the CIC has sponsored a number of cooperative programs in various fields, but the first permitting a free interchange of students started this September. The most formalized approach within the traveling scholar framework is a new program in biometeorology, the branch of science concerned with the influence of weather on man, plants, and animals. This program, sponsored by a three-year-grant from the Division of Air Pollution, U.S. Public Health Service, is directed by Dr. Frederick Sargent II, Professor of Physiology at the University of Illinois and Chairman of the CIC Graduate Training program in Biometeorology. According to Dr. Sargent, "The training grant provides financial support of the inter-campus movements of the student, and allows the student to follow a tailor-made program of study which takes advantage of the eleven cooperating institutions."

A number of courses in the College of Engineering will be available to students participating in the biometeorology program who come to the University of Illinois. These include the sanitary engineering courses under the Department of Civil Engineering that are related to meteorology and air pollution. Dr. Richard Englebrecht, who directs the Sanitary Engineering Group's participation in the biometeorology program at Illinois, remarks that "today CIC Fellows in Biometeorology coming to the Illinois campus can take meteorology and air pollution courses in the College of Engineering. In the future, roving students in other fields, perhaps in various disciplines of engineering, will find a sincere welcome from the College of Engineering, where the common market program is looked upon as one of the real advances in higher education." ◆

Several years ago the University of Illinois Coordinoted Science Laboratory faced o real problem in ultra-high vocuum voltoge breakdawn in its work on the electric vacuum gyro (April, 1963, *Outlaak*). The wark on this problem has continued as a separate project, olthough the specific problem wos solved long ogo. This is an exomple of how a majar research praject can grow out af a need ta solve o specific engineering problem. The device pictured here, built in CSL, is used in the study of voltage breakdown between the two highly polished, optically flat metal electrades under the three circular corono shields.

CONCRETE FRAMES FOR AGRICULTURAL BUILDINGS

Engineering Experiment Station Bulletin 467, *An Investigation of a Reinforced Concrete Rigid Frame for Farm and Light Industrial Structures,* by E. D. Rodda and M. L. Paul, contains information essential to the development of designs employing precast concrete frames. Tests of four knee frames and one complete frame are described and analyzed in the publication. The 34-page Bulletin contains 34 figures and 8 tables. Copies may be obtained from Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, at $2.00 each. ◆

NEW LOOK FOR STUDENT MAGAZINE

The students of the University of Illinois College of Engineering have been publishing *Illinois Technograph* since 1886. Last month they brought out their first issue of this academic year, and it was unlike any *Technograph* of the past. In addition to a new format, the magazine now has a new editorial policy: shorter articles than in the past, more of a "current news" approach, and restriction of subject matter content primarily to University of Illinois happenings. The latter policy is an effort to make *Technograph* a real channel of communications between the students and the faculty of the College of Engineering. For off-campus readers, it is going to make the magazine the most complete source of news about the College of Engineering available anywhere.

Subscriptions to *Technograph* are available for two dollars per year (eight issues). They may be obtained by writing *Engineering Technograph,* 48 Electrical Engineering Building, University of Illinois, Urbana, Illinois. ◆

LONG-TERM RESEARCH PROGRAMS ON HIGHWAY BRIDGES

Countless highway, bridge, and building designs throughout the world have been influenced by two research programs at the University of Illinois that have together spanned 40 years. One of these projects is the research on highway bridge floors which was initiated in 1936 and continued to 1954. The other project, Investigation of Prestressed Reinforced Concrete, was started in 1951 and is still in progress. Both projects were sponsored by the Illinois Division of Highways and the U.S. Bureau of Public Roads.

The purpose of the research program on highway bridge floors as stated in the formal agreement between the cooperating organizations was ". . . to make investigations and tests of reinforced concrete slabs to determine the behavior thereof under varying conditions and to develop information which will advance the art of concrete bridge building." The stated object of the work on prestressed concrete was even more flexible, ". . . to advance knowledge on prestressed concrete and on its use in highway bridges."

Within the framework of these broadly stated directives and without the sterilizing pressure of having to provide immediate answers to specific questions, it was possible to develop a broad base of fundamental information before attempting to find solutions to problems concerning design. Although many years were spent initially in investigating isolated problems and developing experimental techniques and mathematical procedures without any apparent return, this approach paid off when new conditions of design were encountered. Faced with new problems, it was not necessary to retrace steps taken earlier. The basic work provided solutions for the new problems as well as it had for the old ones. Furthermore, the knowledge gained from these two research programs was applicable to other phases of structural engineering, especially for reinforced concrete buildings. Another common feature of both programs was that when recommendations were made for practice, they were adopted throughout the world.

The results of the studies on highway bridge floors were reported in 16 Engineering Experiment Station Bulletins. Those still available are:

Bull. 304, *A Distribution Procedure for the Analysis of Slabs Continuous over Flexible Beams,* $1.00

Bull. 369, *Studies of Highway Skew Slab-Bridges with Curbs: Part I — Results of Analyses,* $ .75

Bull. 375, *Studies of Slab and Beam Highway Bridges: Part II — Tests of Simple-Span Skew I-Beam Bridges,* $ .50

Bull. 386, *Studies of Highway Skew Slab-Bridges with Curbs — Part II — Laboratory Research,* $ .45

Bull. 396, *Studies of Slab and Beam Highway Bridges: Part III — Small-Scale Tests of Shear Connectors and Composite T-Beams,* $1.00

Bull. 405, *Studies of Slab and Beam Highway Bridges: Part IV — Full-Scale Tests of Channel Shear Connectors and Composite T-Beams,* $1.00

Bull. 416, *Studies of Slab and Beam Highway Bridges: Part V — Tests of Continuous Right I-Beam Bridges,* $ .80

Bull. 439, *Moments in Simply Supported Skew I-Beam Bridges (Studies of Slab and Beam Highway Bridges, Part VI),* $1.00.

Some of the results of the investigation of prestressed concrete have been summarized in three Engineering Experiment Station Bulletins, all of which are still available. They are:

Bull. 452, *Investigation of Prestressed Concrete for Highway Bridges, Part I: Strength in Shear of Beams Without Web Reinforcement,* $1.00

Bull. 463, *Investigation of Prestressed Concrete for Highway Bridges — Part II — Analytical Studies of Relations Among Various Design Criteria for Prestressed Concrete,* $1.00

Bull. 464, *Investigation of Prestressed Reinforced Concrete for Highway Bridges, Part III — Strength and Behavior in Flexure of Prestressed Concrete Beams,* $2.00.

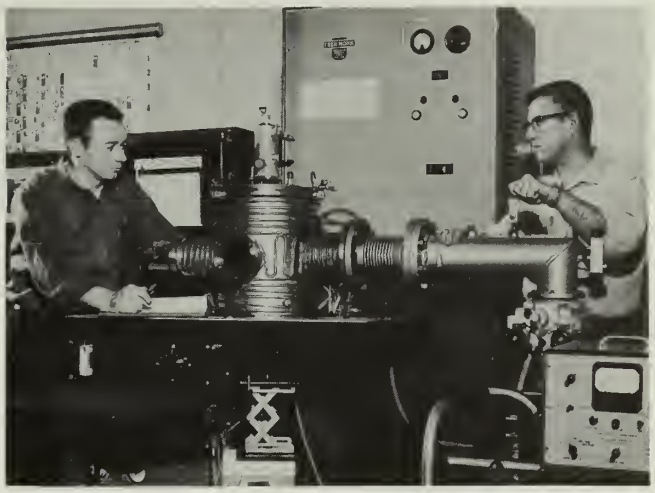
Other important products of these two projects are the men trained in research. More than a dozen of the "graduates" of these two programs are now teaching in various universities throughout the U.S., Canada, Mexico, and South America. The two projects are outstanding examples of the benefits that can be gained from the cooperation of federal and state agencies with the University in long-term research programs. ◆

AERONOMY CONFERENCE

How is the ionosphere formed, how does it disappear, and how can man best use it? These were the basic questions dealt with in the *Conference on Direct Aeronomic Measurements in the Lower Ionosphere,* held this October 21–23 at the University of Illinois. The conference was centered on the use of rockets for ionospheric research and the interpretation of the results of such studies. Professor S. A. Bowhill of the U of I Department of Electrical Engineering was in charge of the conference.

Discussion leaders in the ten areas that were discussed at the conference were: L. G. Smith, Geophysics Corporation of America, Bedford, Mass. (electron and ion density); R. L. F. Boyd, University College, London (electron temperature); E. C. Whipple, Jr., N.A.S.A. (conductivity); C. Y. Johnson, Naval Research Laboratory (ion and neutral composition); W. Pfister, Air Force Cambridge Research Laboratories (impedance); L. J. Cahill, University of New Hampshire (magnetic field); T. A. Chubb, Naval Research Laboratory (solar radiation); N. W. Spencer, N.A.S.A. (pressure and density); M. Dubin, N.A.S.A. (airglow); and S. M. Yen, University of Illinois (supersonic flow and its effects).

An informal conference record of the meeting will soon be available. Interested persons will be able to obtain copies from Prof. S. A. Bowhill, Department of Electrical Engineering, University of Illinois, Urbana. ◆



Members of the reseorch staff in the Ceromic Engineering High Temperature Technology Labaratory prepare to study aeraspace materials heated to re-entry temperatures. They ore ossembling an induction-heated cell used for thermal conductivity, ablatian transpiratian, and diffusian studies of ceromic materials.

AN ILLINOIS SOILS GUIDE

A knowledge of the character of surface deposits is of fundamental importance to all engineers who deal with soils in the design and construction of highways or structures having shallow foundations. A new U of I Engineering Experiment Station Circular, using Illinois data as a guide, illustrates the use of such information by providing a bibliography arranged on a geographic basis, by making engineering interpretations of geologic and soil survey information, and by indicating how engineering problems of design and construction are correlated with natural systems of soil classifications. It includes a brief review of the geology of Illinois, an explanation of the principles of agricultural soil survey, a description of the generalized soil conditions on a physiographic basis, a set of representative soil profiles with their estimated engineering classifications, and a summary of engineering considerations by soil areas.

Circular No. 80, *Surface Deposits of Illinois: A Guide for Soil Engineers,* by T. H. Thornburn, contains 135 pages and is available from Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, for $2.00 per copy. ◆

JANUARY SANITARY ENGINEERING CONFERENCE

The Fifth Sanitary Engineering Conference to be held on the Urbana campus, titled Pumping and Storage Facilities in Water Supply Systems, is scheduled for January 28 and 29, 1964. The conference, sponsored by the Division of Sanitary Engineering, Illinois Department of Public Health, and the Department of Civil Engineering, University of Illinois, is for sanitary engineers, consultants, and water works managers and operators. Papers that will be given will be published jointly by the Illinois Department of Public Health and the Engineering Experiment Station. Further information about the conference may be obtained from Professor B. B. Ewing, 212 Civil Engineering Hall, University of Illinois, Urbana. ◆

PHOTOGRAMMETRY SHORT COURSE

The fourth annual Photogrammetry Short Course at the University of Illinois will be held January 27–31, 1964, on the Urbana Campus. The course will be so conducted that photogrammetrists as well as photointerpreters will benefit from it. Participants will have the choice between two programs: one devoted completely to photogrammetry, and the other treating various aspects of photointerpretation. The program will be flexible enough to allow those interested in both fields to attend the sessions of their choice.

Sessions will be conducted by staff members of the Department of Civil Engineering and the Geography Department of the University of Illinois. A number of guest lectures will be given by prominent photogrammetrists from industry. In addition, carefully designed and closely supervised laboratory exercises will be conducted to demonstrate the principles discussed in the lectures. Some of the latest photogrammetric equipment will be available for such demonstrations.

For further information please contact: Head, Engineering Extension, Illini Hall, University of Illinois, Urbana, Illinois.

PEOPLE AND PLACES

W. L. Everitt, Dean of the University of Illinois College of Engineering, was given the Mervin J. Kelly Award for 1963 for "his outstanding leadership and many contributions in the field of telecommunications" at the National Electronics Conference in Chicago on Wednesday, October 30. At the same meeting he was initiated as an Eminent Member of Eta Kappa Nu, the honorary electrical engineering society.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 4, NO. 10, DECEMBER 1963

THE CHANGING NATURE OF THE COLLEGE OF ENGINEERING

Major changes in the objectives and support of engineering research at the University of Illinois were analyzed by Professor R. J. Martin, Director of the Engineering Experiment Station, at the October meeting of the Engineering Alumni Committee.

Programs of research at Illinois from the founding of the Engineering Experiment Station (1903) to the early 1940's were oriented to applied research and development programs and were virtually independent of the educational programs in the College at either the graduate or undergraduate levels. Most investigations during this period were supported by industry or private funds. But right after World War II, "the large growth of graduate study in engineering as well as the increasing support by federal agencies of basic research introduced a radical change in both the level and objectives of research in our College of Engineering — Engineering Experiment Station." These changes, according to Professor Martin, involved the development of a new type of research program proposed and operated by the faculty with the strong participation of graduate students; the primary source of support became the federal government; the emphasis on applied problems was reduced relative to the total research program; the results of research projects became more suitable for direct use in the classroom; and the previous distinction between teaching and research disappeared.

From these changes, Professor Martin said, has come a change in the character of the College of Engineering: at present one out of four U of I engineering students is a graduate student (1,437 to 5,041); the College confers more than half as many M.S. and Ph.D. degrees as B.S. degrees (485 to 725 last year); about one-half of all faculty time is used in research and thesis advising; for every dollar spent in the educational budget, three dollars are spent on research; and the placement of advanced degree candidates has become a big business.

Professor Martin then remarked that these changes have resulted in better undergraduate educational programs at the University, have given practicing engineers a changing role in the development of new knowledge through their research (the traditional province of the scientist), and have brought about new relationships between the University and industry.

On the last subject he said: "I visualize a new role of the Engineering Experiment Station in its relationship to industry. It is a regeneration of the traditional function of research as a service implemented in one or more of the following ways:

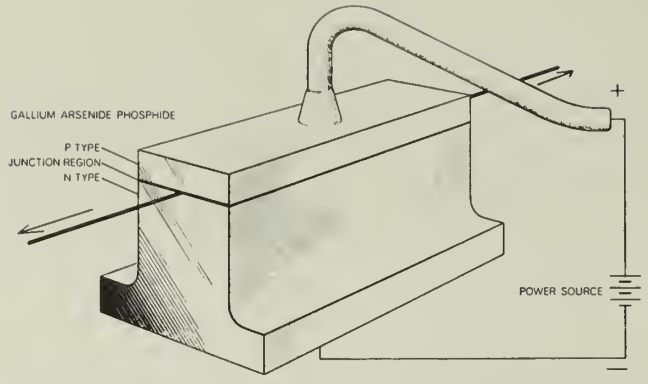
(a) Interpretation of basic research in engineering and the physical sciences for application to the current problems of industry. This may be implemented by special reports, direct consultation between our faculty and industry, research liaison personnel from industry at the University, etc.

(b) Coordination and exchange between basic research now being conducted by both industry and the universities. This could be implemented by more high-level conferences and seminars jointly participated in by industry and universities.

(c) Transmitting research concepts and techniques to industry by highly trained advanced-degree engineering graduates who can contribute to a broad spectrum of research in industry.

(d) Use of 'on-going' research activities as a source of knowledge and techniques for the continuing education of practicing engineers in the field."

Explaining that several of the foregoing concepts formed the basis for the establishment of the Midwest Electronics Research Center and the Production Engineering Educational and Research Center, Professor Martin concluded that the changes in character of engineering research, engineering research support, and engineering education have caused the University to view its relationships to industry in a different light than ever before.



Junction-diode lasers similar to the one in this drawing are currently studied in the University of Illinois Electrical Engineering Research Laboratory under contracts sponsored by the U.S. Air Force.

A SEMICONDUCTOR LASER

One of the strange things about the laser is that more money and more man-hours are being poured into research on the device itself than on its proposed applications. Not since the rapid development of the transistor has so much scientific and engineering interest been turned to such a specialized research area.

Only three years ago the first working laser was developed by engineers at Hughes Aircraft Company. Many industrial and educational research laboratories, including the University of Illinois' Electrical Engineering Research Laboratory (see *Outlook,* February 1961) began pioneer investigations with this new light source. In the "early" lasers the specialized coherent light was created when an electron made a transition between two sharply defined energy levels. Coherency means that all the waves making up the light are in step with each other — crest to crest and trough to trough. For the first two years, most lasers utilized ruby crystals or noble gases as the principal feature of their make-up. However, in the fall of 1962 a new type of laser, a semiconductor P-N junction laser, was introduced. In this laser the light results from electron transitions between the edges of broad energy bands. These "junctions" are pumped by feeding electrons into one side of the junction and holes into the opposite side by direct application of an electric current. This differs from the older ruby crystal and gas lasers in that the direct application of electric current makes the use of flash lamps or gas discharges unnecessary to stimulate the production of coherent light.

At the University of Illinois a team of researchers, headed by Professor Nick Holonyak, Jr., is presently engaged in the study of these new semiconductor lasers. Professor Holonyak, who received his undergraduate and graduate degrees in electrical engineering from the University, was formerly with General Electric. He has been a pioneer worker in junction laser technology, having developed the first junction-diode laser to operate in the *visible* region of the spectrum. Presently extending his experimental program on these lasers in the Electrical Engineering Research Laboratory, Dr. Holonyak has a working model which is so tiny that hundreds of them can be put in a thimble. Measuring 1/100" long, 1/50" wide, and 1/200" high, this tiny speck has the ability to achieve *any* wavelength between 8400 and 6400 angstrom units. In addition, the laser developed by Holonyak is remarkably efficient, compared to ruby or gas lasers, in converting electrical energy into light, and it requires relatively little accessory equipment to put it into operation. The current in this miniature laser can run up and down at kilomegacycle rates. This means that the laser is thus more versatile than previous lasers because it has a much higher speed.

Dr. Holonyak and his group at the University of Illinois are presently concentrating on improving the design of the junction-diode laser. Their emphasis, like the emphasis of most researchers in this rapidly expanding field, is mainly on attempting to understand this device better. Applications ranging from the use of lasers for an improved TV communications network to its use as an advanced tool for human surgery have been proposed by researchers in the field, but few of the devices have actually been put to use. Most laser researchers, like Dr. Holonyak, feel that possible applications for lasers are potentially vast; therefore they feel no constraint about concentrating on design improvements before turning their attention to specific applications. ◆

NOR ANY DROP TO DRINK . . .

The alarming possibility of an acute national water shortage, made more crucial by the population explosion and accompanying industrial expansion, has recently been well publicized by television and other news media. In response to this urgent problem, the University of Illinois is increasing its activities in the field of hydrology. By accepting membership during 1962 in the newly formed Universities Council on Hydrology (as reported in the January 1963 *Outlook*) it joined 16 other institutions in a central body which supports the study of water resources.

In addition, the University of Illinois has established its own Water Resources Center, administered by the Graduate College, which will conduct programs in the College of Engineering as well as in the Colleges of Law and Liberal Arts and Sciences, the Engineering and Agricultural Experiment Stations, and the Illinois State Water, Geological, and Natural History Surveys. Besides coordinating intra-university hydrological activities, the Center will administer grants and review proposals to the University or outside agencies for support of research on water resources.

Nor is the University neglecting its educational function concerning hydrology. It has granted more than half of all doctorates earned nationally in ground water geology, as well as many doctorates in sanitary and hydraulic engineering. Recently, in mid-October, the Department of Civil Engineering began teaching a two-month-long graduate course on "Water Resources Planning" to professional personnel of the U.S. Army Corps of Engineers. The course is designed to help overcome the present shortage in the Corps of Engineers of personnel qualified to plan river basin projects and development of water resources. Primary emphasis is on the best use of water resources to meet all foreseeable short- and long-term needs. Enrolled in this program are 46 men from 19 states, including one student from Alaska. The participants, nearly all of whom are civil engineering graduates, represent 36 colleges and universities. ◆

PORTION OF PHYSICS THEORY DISPROVED

The laser has made possible another concise test of an old theory, and the old theory has been found — in one respect — to be wanting.

Called into question is a prediction made by the great English physicist Lord Rayleigh in 1871 about the intensity of different kinds of polarized and unpolarized light scattered at different angles by the molecules of a gas such as argon.

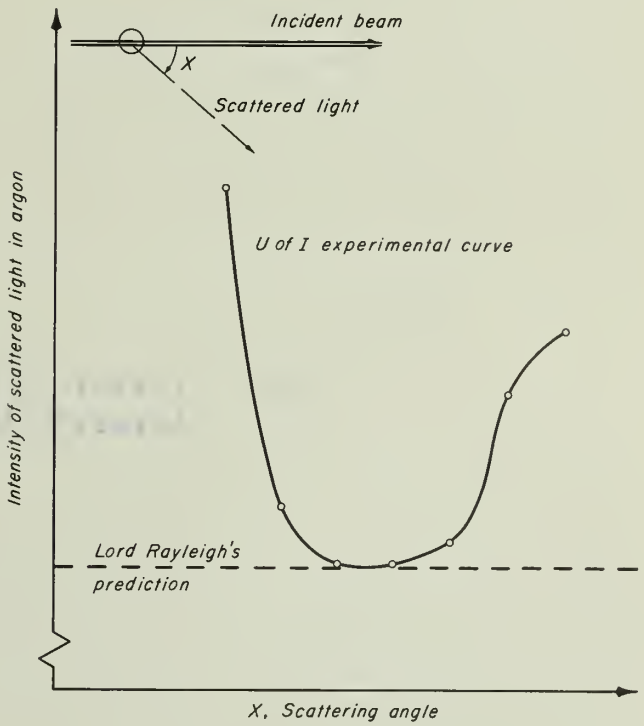
Rayleigh's theory describes a case in which a straight beam of light passes through a chamber full of gas (at a given temperature and pressure) whose molecules scatter light out of the path of the beam. One of the theory's predictions is that the intensity observed in the horizontal plane of vertically polarized light scattered from the beam will be the same whether it leaves the beam at an angle of 35 degrees, 130 degrees, or any angle in between.

A group of University of Illinois physicists and engineers, T. V. George, L. P. Slama, M. Yokoyama, and L. Goldstein, have found that for vertically polarized coherent light, Lord Rayleigh's prediction is not verified by experiment. The intensity of vertically polarized light (light composed of electrical vibrations in the vertical plane at right angles to the direction in which the light travels) is related to the angle at which the light leaves the beam. It was discovered to have different intensities at different angles. However, the researchers found the other predictions of the Rayleigh theory to be in good agreement with their experimental results.

The fact that the University of Illinois researchers used a pulsed ruby laser as a light source enabled them to overcome experimental difficulties that had defeated previous efforts to test Rayleigh's scattering predictions. Systematic investigations and tests confirming Rayleigh's predictions of the amount of light scattered at right angles to a beam's path by a gas were made by the French physicist Jean Cabannes (who began work in 1915) and Lord Rayleigh, who started experimental work on the problem in 1918. Neither worker, however, was able to measure the intensity of polarized light scattered at other angles. They were hampered by "spurious light" — light reflected randomly within the apparatus which masks the intensity of the scattered radiation. Furthermore, the sides of their light beams diverged, making it difficult to say at precisely what angle to the beam the measurements were being made.

A laser produces a straight, pencil-thin beam of light whose sides diverge little. Consequently, the angles at which light departs from it can be measured. A carefully designed experimental system kept "spurious light" at acceptable levels.

The U of I research team did verify Rayleigh's prediction that the intensity of scattered, horizontally polarized light (light composed of horizontal vibrations) depends on the angle at which it leaves the beam. In other words, a measurement at one angle shows a different intensity from that at another. They tested Rayleigh's scattering predictions by observing the interaction between the laser beam and argon, which was at room temperature and atmospheric pressure. Measurements of the amount of radiation scattered were made on



The angular distribution of scattered light shows the difference between the experimental observations obtained recently in the U of Goseous Electronics Laboratory and Lord Rayleigh's 1871 prediction.

several different gases, including argon, neon, xenon, air, oxygen, and nitrogen.

The four researchers reported their work in the November 1 issue of *Physical Review Letters*. The University of Illinois experiment leaves physicists with the problem of finding out why Rayleigh's predictions were right in the case of horizontally polarized light and wrong for vertically polarized light. ◆

AN ENGINEER'S NIGHT BEFORE CHRISTMAS
or
A BIT OF ADVICE FOR SPACE AGE DESIGNERS*

Twas the night before Christmas, and all thru the plant,
Not a creature was working but me and Van Zant.
The specs were all written and ready to go,
In hopes that the drawings would soon be, also.
A batch had been finished, and already checked
But others were not, as you might well expect.
So we, both as zealous as Scrooge's poor clerk,
Had just settled ourselves for a long evening's work —
When out on the lawn there arose such a clatter,
We sprang from our desks to see what was the matter.
The security lights on the new-fallen snow
Gave the luster of blastoff to objects below.
When, what to our wondering eyes should appear,
But a miniature space capsule and eight tiny (but extremely powerful) hydrazine-propellant boosters tandem mounted in series so the pilot could steer;
And a little round astronaut, so lively and quick,
I thought for a moment he might be Saint Nick.
But then Van Zant asked me, "Did you hear him yell
All those names to his boosters as his capsule fell?
'Now Atlas! now Saturn, now Vanguard and Gemini!
Let's make our next landing beside that old chiminey!
On Nike! on Redstone! on Titan and Polaris!
It's only tonight that Canaveral can spare us!' "
As we drew in our heads and were turning around,
Down the chimney the astronaut came with a bound.
He was dressed in a spacesuit from his head to his foot,
And his clothes were all tarnished with ashes and soot;
"This soot," he said, smiling, "is not from your chimney,
It's caused by the heat of atmospheric re-entry!"
A wink of his eye and a twist of his head
Soon put us at ease, although he then said:
"Tell me, are your schedules really so tight,
Or do you get overtime for working tonight?"
I looked at Van Zant; then he looked at me;
I said, "It's a matter of deadline, you see . . ."
"We've got a tough problem," Van Zant said with a groan,
"In hanging the micronite up in the T-zone."
The astronaut chuckled, "Well, that's why I'm here,
In packaging, I was the first engineer."
He spoke nothing more, but went straight to the work,
And studied the problem; then turned with a jerk,
He smilingly told us to take a good look,
And held out a Christmas tree ornament hook.
Even though we both knew he had found the solution,
By then we felt ripe for a state institution.
"Well, fellows," he said, "All your systems are go;
It looks A-OK, so I've now got to blow."
And laying a finger astride of his nose,
And giving a grin, up the chimney he rose.
He sprang to his capsule and into the door,
And then blasted off with a Titanesque roar.
"Happy Christmas," he yelled, as he flew out of sight,
"Keep your stuff simple and it's bound to be right!"

* Reprinted by popular demand (def.: more than three people).

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 5, NO. 1, JANUARY 1964

YOUR WATER BILL IS FOR MORE THAN JUST WATER

Sanitary engineers are continuously interested in the quality of the water that is distributed to the home. They are concerned about the deterioration of water quality between the time the water is treated and when it arrives at the tap; corrosion in the distribution system; bacteria and viruses in water supplies; the amount of minerals and chemicals in the water; and many similar questions. In an effort to compare ideas on such problems, sanitary engineers from all over the country met at the University of Illinois last January for the fifth of a series of annual Sanitary Engineering Conferences sponsored by the Illinois State Department of Public Health and the University of Illinois.

The proceedings of the Fifth Sanitary Engineering Conference, titled *Quality Aspects of Water Distribution Systems,* has just been published as Engineering Experiment Station Circular 81. This ninety-five-page booklet, which contains fourteen papers given at the Conference last January, is available for two dollars per copy from the Engineering Publications Office, University of Illinois, Urbana. Proceedings of the last three Sanitary Engineering Conferences — Circular 69, *Radiological Aspects of Water Supplies;* Circular 71, *Disinfection and Chemical Oxidation in Water and Waste Treatment;* and Circular 75, *Water Distribution Systems* — are all still available at two dollars per copy. The entire series of four are available at the bargain price of eight dollars. ◆

SEVEN OUT OF TEN FRESHMEN COMPLETE DEGREES

Common ideas about the rate of college dropouts are drastically reversed in a study of college men by the University's Office of Instructional Research. Although many people have said that 40 to 60 per cent of students who begin college never earn degrees, this study shows that 70 per cent achieve degrees within ten years of starting in college. It also indicates that nearly twice as many starters graduate within ten years as do within four years.

The study involved 1,332 men who came to Illinois as freshmen in 1952. A 94 per cent return was achieved in data obtained. It shows that of every ten freshmen who came to the campus in 1952, seven had college degrees ten years later. Five earned their degrees within four years; of the five who had dropped out during the four years, three had come back to college; and of those who did not have degrees, some were still working toward them. It appears that a change of curriculum or a dropout doesn't necessarily mean that a student's college career is permanently ended. ◆

CREEP DATA AVAILABLE

Everybody hates a creep, whether it is the human type or the equally obnoxious engineering headache defined as slow plastic deformation under stress.

Knowledge of creep behavior is important because it helps solve such diverse engineering problems as those of bolts becoming loose under stress, premature buckling of structural columns, the sagging of long-span cables, the weakening of prestressed concrete beams, the excessive deformation of machine parts at high temperatures, and a host of other technological headaches. Because virtually all solid materials creep to some degree when subjected to stress, increased attention is currently being paid to both theoretical and practical approaches to lessen its effects.

A new University of Illinois Engineering Technical Report by Professor O. M. Sidebottom and Mr. N. Patnaik of the department of Theoretical and Applied Mechanics contributes to a better understanding of the troublesome creep phenomena. Technical Report 6, *Creep of Circular-Section Torsion-Tension Members Subjected to Nonproportionate Load Changes,* is a concise theoretical study containing fundamental data relating both to creep in general and to the time-dependent effects of creep. It is available from the Engineering Publications Office at $2.00 per copy. ◆

These ore some of the University of Illinois engineering students who moke up the locol chopter of the notionol Society of Women Engineers. The chopter received its chorter in the notionol Society lost November. Potricio Mortin, o senior in Aeronouticol ond Astronouticol Engineering (second from right, top row), is chopter president. Miss Groce Wilson, Associote Professor of Generol Engineering (not shown), is the group's foculty odvisor.

ARMA VIRUMQUE CANO

Vergil sang of arms and the man; once a year, the Engineering Publications office sings of research and the engineer — or at least once a year we sing of all of them at the same time. We call the production the *Summary of Engineering Research.* The 1963–1964 edition is now available.

This annual publication describes the 439 research projects under way at the College of Engineering during fiscal 1963. For this period the total research budget, as indicated in the *Summary,* exceeded 12 million dollars, of which 10 million came from federal government sources, less than 1 million came from state and private sources, and close to 2 million came from the general funds of the University.

Amply illustrated with photographs, the approximately 200 pages of the *Summary* are divided into sections devoted to the various departments of the College as well as to certain other related departments. Within these departmental sections, listings of individual research programs indicate the project title, investigators, publications and theses resulting from the program, and a brief description of the work.

Additional sections of the *Summary* discuss the objectives, achievements, and financial support of research at the College, as well as the advent of the Midwest Electronics Research Center and the Production Engineering Educational and Research Center.

The *Summary of Engineering Research* is available without charge from the Engineering Publications Office, 112 Civil Engineering Hall, Urbana, Illinois 61803. ◆

NEW CURRICULUM GUIDE FOR JUNIOR COLLEGES

"Despite the high level of unemployment, there is a critical shortage of competently trained technical manpower in our nation." So begins a forty-page booklet, *Training Program for Highway Engineering Aides,* prepared with the assistance of University of Illinois engineering faculty and issued by the Office of Education of the U.S. Department of Health, Education, and Welfare. This sixteen-week training curriculum for badly needed personnel in the highway field is designed, under the provisions of the Federal Manpower Development and Training Act, to alleviate unemployment and the paradoxically coexistent technician shortage. Acting as project supervisors for the program were Professors J. S. Dobrovolny and B. O. Larson of the Department of General Engineering, with additional contributions by Professors Ellis Danner, J. W. Hutchinson, and T. T. Thornburn of the Department of Civil Engineering.

Administered by the Department of Health, Education, and Welfare, the curriculum will train applicants selected by public employment service offices in the various states. The booklet is designed to aid administrators, supervisors, teacher-trainers, and teachers in the promotion and development of vocational courses. The course outlines and other materials were prepared by the University of Illinois, with faculty members of the College of Engineering and consultants from industry participating in the development of program content.

The booklet covering the sixteen-week training program presents course outlines and describes the selection of students, the requirements of teaching staff and equipment, and the general objectives and content of the program. An appendix provides sample problems, equipment costs, and a laboratory layout. Although only a limited number of copies are available, single copies of *Training Program for Highway Engineering Aides* may be obtained by writing to the U.S. Office of Education in Washington, D.C. ◆

A COLLEGE–INDUSTRY PROGRAM FOR STUDENTS

Today an increasing number of students in the University of Illinois College of Engineering are enrolled in a co-op program — a modern way to have your cake and to eat it at the same time. These students alternate periods of schooling with periods of working in industry. The student's employment is related to his field of study and his work assignments increase in complexity as he progresses through his college curriculum. His rate of pay is increased each academic year that he works for the co-operating company. The entire program extends a normal four-year curriculum to five years.

The College of Engineering has established co-op programs with several outside organizations: Rock Island Arsenal; McDonnell Aircraft; NASA (at Edwards Air Force Base, California); and Allis-Chalmers. Students now participating in these programs are generally quite happy with them. In an article in the October issue of the *Technograph,* the University of Illinois student engineering magazine, mechanical engineering sophomore Lawrence Heyda lists four important benefits he feels he is receiving from the co-op program: money to finance his education, valuable industrial experience as part of his education, a chance for a higher starting salary on graduation, and a chance to explore the various types of engineering work in a company (such as manufacturing and service, design and analysis, research, etc.). Heyda's experience is typical of the co-op student.

The program is an example of cooperation between University and industry for the achievement of goals benefitting both. ◆

AERIAL SURVEYING TECHNIQUES

Engineering Experiment Station Technical Report 5, *Studies in Spatial Aerotriangulation,* by H. M. Karara, describes the cross-bases method of aerotriangulation, a photogrammetric technique that reduces the amount of ground surveying necessary for the production of maps of large areas. The booklet contains two chapters and six appendices. The first chapter deals with and explains the cross-bases method. The second describes the capabilities and limitations of spatial aerotriangulation in reducing the amount of ground control necessary for photogrammetric mapping. The appendices give the derivations of some of the important formulae used in the two chapters. *Studies in Spatial Aerotriangulation* is available for one dollar per copy from the Engineering Publications Office, University of Illinois, Urbana. ◆

CREATING A STORM IN THE LABORATORY

Natural rainfall and the amount of runoff, so important to the hydraulic engineer, cannot be controlled by human effort or verified by laboratory experiment. Artificial rainfall and the resulting runoff that can be measured in the laboratory will soon be a part of hydraulic engineering research at the University of Illinois.

The rainfall simulator will be constructed of thousands of hypodermic needle points mounted on a steel frame of adjustable height. The needle points will be connected in groups to a number of electronically operated direct displacement pumps. The pumps will force water through the needle openings to produce fine drops of artificial rainfall. The instrumentation will be designed to create storms of variable rainfall intensities and variable movement speeds. Artificial storms will be produced that can move across a model watershed in upstream, downstream, or other desired directions. The electronically measured runoff from the model watershed will be recorded on punched cards or tapes for computer analysis. The objective of the research is to investigate the basic laws of the flow of water on drainage basins by means of controlled experiments.

The construction of this equipment and the research done with it will be directed by Dr. Ven Te Chow, Professor of Hydraulic Engineering in the Civil Engineering Department. Dr. Chow is the creator of a new method of scientifically determining culvert sizes (*Outlook,* October 1961), the inventor of a special slide rule to use in making related determinations, and the author of Engineering Experiment Station Bulletin 462, *Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basins,* which describes the method, its application, and its derivation. The artificial rainfall project is financed by the National Science Foundation. ◆

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- ☐ Circ. 80, *Surface Deposits of Illinois: A Guide for Soil Engineers,* T. H. Thornburn. *Two dollars.*
- ☐ Circ. 81, *Quality Aspects of Water Distribution Systems,* the Proceedings of the Fifth Sanitary Engineering Conference. *Two dollars.*
- ☐ *A Summary of Engineering Research, 1963–64. No charge.*
- ☐ *Engineering Calendar,* a weekly calendar of seminars and discussions at the University of Illinois. *No charge.*

SUMMER INSTITUTE IN ELECTRONICS AND MACHINE DESIGN

Forty instructors from junior colleges and technical institutes will attend an eight-week summer institute in 1964 at the University of Illinois. The program, scheduled from June 15 to August 8, will be divided into two curricula, one in electronics technology and one in machine design technology. Participants of both groups will attend classes limited to twenty hours of a five-day week, in addition to a seminar on technical education held twice a week. Applicants should have two years of teaching experience in one of the major fields and be under fifty years of age. The University will reserve housing for single persons or families upon request. This is the fourth year that these summer programs, supported by the National Science Foundation, have been held at the University of Illinois. All participants will receive financial assistance in the form of allowances for dependents and travel, as well as $600 stipends. Further information and application forms are available from Professor J. S. Dobrovolny, 115 Transportation Building, University of Illinois, Urbana, Illinois. ◆

PEOPLE AND PLACES

Metallurgy and Mining Building is the new name for the former Laboratory of Physics at the University of Illinois. The change followed the move of physics activities to the University's new Physics Building and the occupation of the older structure by the Department of Mining, Metallurgy, and Petroleum Engineering.

Dr. Heinz Von Foerster, head of the Biological Computer Research Laboratory of the University of Illinois Electrical Engineering Department, has been elected president of the Wenner-Gren Foundation for Anthropological Research.

On September 1, 1963, **Dr. Robert B. Banks** was appointed Dean of the University of Illinois College of Engineering at Congress Circle, Chicago.

Dr. M. A. Sozen and **Dr. H. M. Karara,** Associate Professors of Civil Engineering at the University of Illinois, have been awarded research prizes by the American Society of Civil Engineers. Dr. Sozen's award was in recognition of "an outstanding contribution to the knowledge of the strength and behavior of prestressed concrete members." Dr. Karara's award was for "an outstanding contribution to the knowledge of aerotriangulation and photogrammetric engineering."

Dr. Frederick Seitz, Head of the Physics Department, has been appointed Dean of the Graduate College and Vice President for Research at the University of Illinois, effective September 1, 1964. Initially he will serve on a half-time basis while continuing as President of the National Academy of Sciences during part of 1964–65.

Doctor E. W. Ernst, Professor of Electrical Engineering at the University of Illinois, has been elected president of the 1964 National Electronics Conference to be held in Chicago next October 19–21.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 5, NO. 2, FEBRUARY 1964

HOW TO TALK TO A COMPUTER

The electronic computer, one of man's most useful tools, is not easy to communicate with. In a few words or short sentences one engineer can give another engineer "instructions" for performing a complex task, but he must give a computer hundreds or thousands of instructions to make it do the same job. Not only is this method of instructing far removed from the engineer's normal way of thinking, but it makes programming time-consuming and expensive. This tends to stereotype the engineer's work because of his inclination to use already-existing programs. A project to develop a means of communicating with computers in everyday or "problem-oriented" language is currently in progress in the University of Illinois Department of Civil Engineering.

This project, which is directed by Dr. S. J. Fenves, is aimed toward the development of a system through which the computer can be "instructed" by the same words one engineer would use to instruct another. The initial work is specifically directed toward programming the computer for structural analysis problems, but eventually the system will be applied to other phases of structural engineering such as structural mechanics, design, detailing, specification checking, quantity takeoff, and erection scheduling. The system has been designated the *Str*uctural *E*ngineering *S*ystem *S*olver (STRESS). STRESS is actually a computer program or processor that serves as an interpreter which accepts problem-oriented language and translates it into computer language. When the system is in use, the engineer has complete freedom in describing his problem in his own terminology, as well as in specifying the alternatives he wishes to investigate. The system is designed so that additional components or procedures can be easily incorporated. After one hour of instruction, undergraduates who were previously unfamiliar with computer programming have been able to use the system. It holds promise for use in other fields of engineering where researchers feel that a quick answer deserves a quick question. ◆

ELECTRONIC SIMULATION MEETING IN MARCH

A one-day meeting of the Midwestern Simulation Council with the topic "Hardware Evaluation by Users" will be held on the University of Illinois campus next March 16. The Midwestern Simulation Council is a regional unit of Simulation Councils, Inc., a technical society concerned with electronic analog and hybrid computation. The meeting is designed to give attendees an opportunity to get to know each other and to discuss mutual problems. Further information on the meeting may be obtained from Professor M. S. McVay, 376 Electrical Engineering Building, University of Illinois, Urbana 61803. ◆

URBAN HIGHWAY PLANNING LIAISON BOOKLET

The University of Illinois Engineering Experiment Station has just published Technical Report 7, *Urban Highway Planning Liaison* by J. M. Heikoff. This 42-page booklet presents a summary of investigations in the following areas:

(1) the nature of the problem of liaison between state highway agencies and local governments in urban highway planning;

(2) the knowledge and skills that personnel experienced in urban problems and planning for urban development may contribute to highway administration;

(3) the location of such personnel in the organizational structure of a state highway department; and

(4) a definition of duties and responsibilities of planning liaison personnel.

Its nine chapters are entitled Introduction, Technical Contributions by Planning Liaison Personnel, Integration of Highway and Urban Planning Techniques, State-Local Communication in Urban Highway Planning, Planning Liaison Unit Functions and Organization, Personnel Policies, Some Examples of Planning Liaison in State Highway Departments, Appendices, and Bibliography. Technical Report 7 is available from Engineering Publications, University of Illinois, Urbana, for one dollar per copy. ◆

There is more to this University af Illinais radiatian pattern range thon meets the eye. Althaugh even a casual abserver can see the tapmost antenna maunting base located in the center of the 20-faat movoble baom, a secand antenna and recarding apparatus are conceoled in the frame structure belaw. When on antenna is mounted in the baam and roised ar lowered, it transmits signals to the ontenna below. The variatians in the directional praperties af the lower antenna, which are o function of the changing angle of the boom, are drown by the recording apporatus on palar graph paper.

HOW IS PHYSICS RELATED TO POETRY?

. . . or, to phrase the question differently, who will be the research director of tomorrow? A physicist? An electronics expert? A business manager? It is more likely he will be a zetetist — a man well oriented in the relationships between literature, physics, electrical engineering, political science, and other areas of interest to humankind.

Zetetics has been formulated over the last thirty years by Joseph T. Tykociner, Professor of Electrical Engineer, Emeritus, at the University of Illinois. Professor Tykociner "retired" in 1949 but formally came out of retirement in 1962 at 84 to teach zetetics, the science that is based on the premise that all bits of human knowledge are interdependent and interrelated. One of the major tasks of this new science is to lay out a "blueprint" of the known to permit intelligent focusing on the not-yet-known. This includes a study of the origin and classification of systematized knowledge, a search for interrelations between the sciences, an investigation of the mental processes behind research and creativity, and an analysis of the social conditions fostering such knowledge. As an area of knowledge, zetetics serves to counterbalance the increasing trend toward specialization by emphasizing methods of synthesis. Its motto might well be "a little (narrow) knowledge is a dangerous thing. . . ."

Professor Tykociner has classified systematized knowledge into twelve areas: the arts, symbolics of information (e.g., linguistics and logic), sciences of matter and energy, biological sciences, psychological sciences, social sciences, sciences of the past (e.g., evolution and history), sciences providing for the future (e.g., creativity and the selection of problems), and integrative sciences (e.g., philosophies and theologies). Each of these areas contain major sciences, sub-groupings, and links which bind and relate each science to the other.

From the process of systematizing areas of knowledge in this way, the science of zetetics tends to raise possibilities of looking at current problems from an over-all, long-range, and international viewpoint. Should we put a man on the moon by 1970? The zetetist, from his "overview" position, tends to look at the many hidden ramifications in such a question. He sees that it is a national, rather than international, problem, and yet not a problem of national survival. He looks at the tremendous resources involved, not only in money and equipment, but in brainpower. He considers other current, human needs, and examines what effect the priority being given this problem will have on the solution of other problems. Because of his tendency to think in this way, he appears to be a better choice to serve as an advisor to the man who must ultimately make such decisions than the narrow specialist would. He considers it one of the tasks of zetetics to indicate how such priorities fit into the whole picture of man's knowledge and endeavor.

It is in this sense, then, that Prof. Tykociner sees a relationship between every area of human knowledge and endeavor. Everything done by man answers one of his needs and somehow makes his life fuller and richer. In all past recorded history things have essentially been done on a chance or expedience basis: a man has studied a particular subject because he simply felt like it, a certain amount of time or money has been dedicated to a project because of a pressing social situation of the time, or work has been undertaken simply because of the momentary needs of technology or commerce. In one sense, zetetics tells us, all of these reasons are unquestionable — it has always been that way to some extent, and always will and should be. Yet, the zetetist asks, should we not decide *what* to do next and *when* to do it with the same intelligence that we focus on the specific prob-

lem itself? Science and technology is a case in point. In the fledging days of science, the scientist was a natural philosopher, an individual doing things that had no great immediate social consequence. He was also a generalist: he felt he could say "I take all knowledge to be my province." Today scientific work requires tremendous resources and has tremendous social impact, and the growing fund of new knowledge makes every participant a specialist, interested only in his own affairs and his own work. Science today is like a huge ship operated by many specialists, none of whom is a navigator.

We are living in an age in which man's store of knowledge can double within one or two generations. We are living in a period of time in which our ability to create new devices has gotten ahead of our ability to apply them in the interests of society. While many people believe that history does not offer clues to the future, the zetetist feels that evolution and history, from his "overview," show indications of what the future has in store. Predictions are never comfortable — they may be partly or altogether wrong. The zetetist points out that we operate on the basis of predictions all the time — and we learn from our mistakes. He feels that predictions must be made and made as intelligently as possible. To do this, he believes, one must study and understand the close relationships between the many areas of arts and sciences — and this is the main function and interest of zetetics, the science of the future. ◆

MARCH HIGHWAY ENGINEERING CONFERENCE

Half a century ago the first annual meeting of highway engineers was held on the Urbana campus of the University of Illinois at the request of the newly created Illinois State Highway Department. Next month the 50th Annual Illinois Highway Engineering Conference will be held on the University campus, marking the golden anniversary of this event and symbolizing the continuous, active cooperation of the University in the development of highway programs in Illinois.

A portion of the 1964 Conference, to be held March 3, 4, and 5, will be set aside for a review of the history and probable future of Illinois highway transportation. The rest of the program will be devoted to items of current interest such as maintenance problems, construction of continuously reinforced pavement, and uses of soil exploration and mapping data. As usual, a portion of the program will consist of a review of the current status and findings of highway research projects being conducted by the U of I Department of Civil Engineering in cooperation with the Illinois Division of Highways and the Bureau of Public Roads.

The Annual Illinois Traffic Engineering Conference, which has been held in conjunction with the Highway Conference for the past fifteen years, will begin on the morning of the last day of the Highway Conference, March 5, and continue through March 6. The program will include many traffic topics of current interest, with special emphasis on planning for traffic improvements and operating existing facilities at optimum efficiency. ◆

SIX-WEEK PROGRAM FOR SECONDARY SCHOOL STUDENTS

The Illinois Junior Engineering Technical Society and the National Science Foundation will co-sponsor a six-week summer program at the University of Illinois from June 22 through July 31. Approximately 40 students who will be Illinois high school seniors in the fall of 1964, ordinarily those in the upper ten per cent of their classes, will be eligible for the programs. The deadline for applications is April 1, 1964.

Application forms may be obtained from Professor J. S. Dobrovolny, Director, 117 Transportation Building, University of Illinois, Urbana. The Summer Program, like the JETS Program, is intended to stimulate interest in engineering among outstanding high school students and give them a chance to see for themselves the many career opportunities in engineering. ◆

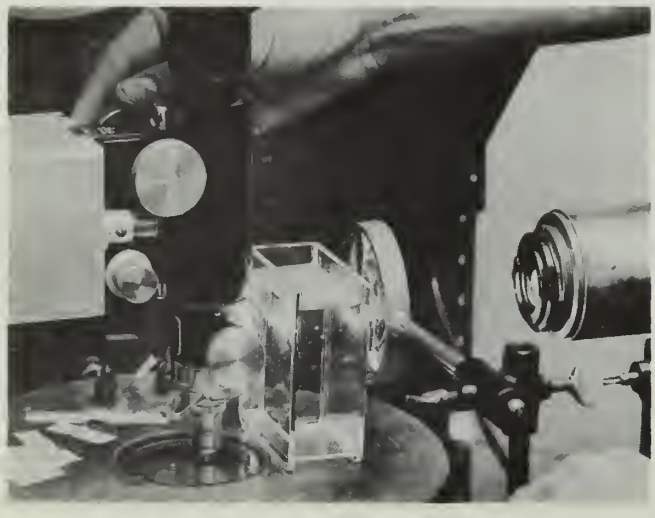
Pragress in research to make new uses af light in cammunications has been stimulated by recent University af Illinais studies. Professar O. L. Gaddy mokes adjustments on this optical maser which wos built in the Electrical Engineering Reseorch Laboratory. When this device is used in canjunction with o new photomultiplier olso designed by U of I reseorchers, it will detect extremely low-powered optical signals.

PEOPLE AND PLACES

Dr. Bernard I. Spinrad, Senior Physicist at Argonne National Laboratory, is on the University of Illinois campus during this semester as a Visiting Professor of Nuclear Engineering. He is teaching a course in space applications of nuclear energy, advising graduate students on thesis topics, and working with staff members on program development in the thermonuclear and nuclear space areas.

Ellis Danner, Professor of Highway Engineering at the University of Illinois, has been appointed by Governor Kerner to serve on a seventeen-man Commission to Investigate, Study, and Formulate a Highway Plan for Illinois.

Next fall 35 to 40 promising engineering students will be able to attend the University of Illinois because of the generosity of a former student, C. B. Niccolls, class of '99. The fund left in his memory, the Calvin Barnes Niccolls Scholarships fund, is one of the largest ever given to the University: $500,000.



Determination of nucleation sites for water droplets is one of the research projects of the Department of Chemicol Engineering. Photography through a microscope reveals possible sites, including minute pits, scratches, ond specks. In the upper picture, groduote student J. L. McCormick views the drops, greatly enlarged, while his hands, shown concurrently in the lower picture, focus the microscope on o horizontol plote upon which water vopor condenses slowly.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 5, NO. 3, MARCH 1964

UNIVERSITY OF ILLINOIS THIRD IN SCIENCE DOCTORATES

The University of Illinois ranked third in the nation for the awarding of doctoral degrees in all fields of science in the period 1949–50 through 1958–59, according to a report recently issued by the U.S. Office of Education entitled *Degrees in the Biological and Physical Sciences, Mathematics and Engineering.* The study states that the U of I was fifth in producing the greatest number of doctorates in all fields, and ranked as follows in the specific fields of the study: chemistry, first; biological sciences, fifth; engineering, second; mathematics, sixth; physical sciences, third; geology, sixth; physics, fifth. ◆

A THREE-MILE-LONG TWINKLE

How much data in a mile of tape? This is no idle question to University of Illinois researchers who distill ionospheric information from tape recordings and reams of ink-traced graph paper.

One researcher, graduate student J. Philip McClure, is currently studying irregularities of the ionosphere 200 miles above the earth by means of "radio shadows." These irregular diffraction patterns of radio signals cause a twinkling effect similar to the twinkling of light from stars. The difference, of course, is that McClure's "twinkling" is "seen" with a radio receiver. The signals are pumped into a strip chart recorder and the information is traced on graph paper for analysis by McClure, who is working for his doctor's degree under Professor George W. Swenson, Jr., of the Electrical Engineering Department.

McClure is studying the ionospheric irregularities — their height, thickness, shape, position, and day-to-day changes — by using the radio shadows of transmissions from a Navy satellite, Transit 4-A, which is orbiting the earth. The satellite, whose signals are designed to aid navigation of ships and submarines, crosses over the U of I campus at 18,000 miles an hour twice a day at an altitude of 600 miles. For a year and a half, McClure has recorded these signals with four radio receivers located 2 to 10 miles apart on a line. He is currently interpreting and analyzing differences between records from each point.

One of the satellite's daily passes is from northwest to southeast, parallel to the line of receivers, the other from southwest to northeast, across the line of receivers. Records made by the four stations during the parallel pass are quite similar, but with a time shift (increasing from first to last) which reveals the height of the ionosphere irregularities. The rate of change of the records is related to thickness of the irregularities.

Records made when the satellite passed at right angles to the line of receivers show another pattern from which the size and shape of the irregularities can be measured. They move at 100 miles an hour, which is very slow compared to the satellite. They have been found to be cigar shaped, about 3 miles long and ½ mile wide, with their long axis parallel to the earth's magnetic lines of force.

The University of Illinois is also engaged in another project investigating the dispersion of ionospheric irregularities. These irregularities are not found equally all over the globe, but are concentrated in latitudes above 40 degrees of each hemisphere and possibly at the equator.

For this project, radio receivers and recorders are located at the U of I Geophysical Laboratory, near the Urbana-Champaign campus; at Michigan Technological University, Houghton, Michigan; Baker Lake, in northern Canada; and Adak Island, Alaska. From these observatories, the U of I is also measuring the number of electrons in the ionosphere by observing the Faraday rotation during each satellite pass at each station.

The U of I ionospheric investigations are sponsored by the National Aeronautics and Space Administration. ◆

Not oll engineering research deals with the inanimate. A porticipant in the fluid mechonics research progrom af the University of Illinois Department of Theoreticol and Applied Mechanics, Prafessor M. E. Clark is concerned with flow ond pressure patterns in the Circle of Willis, the arterial blaod distributian system ta the brain. Here Prafessor Clark (right), with research ossistant R. E. Wenglarz, considers the correlation between a madel and an onatamical drawing of the Circle of Willis.

HOWDOSPOKENWORDSSOUND?

Ask most engineers what a bridge is made of and chances are they will say "steel and concrete." However, if you ask a group of specialized engineers at the University of Illinois Biological Computer Laboratory the reply could conceivably be — "words and sounds." These researchers, under the direction of Dr. Heinz Von Foerster, hope to use non-material elements to build a communications bridge between man and machine.

A serious obstacle to the completion of the "bridge" — a reliable system for the recognition by machines of voice commands — is segmentation. This term roughly means that whereas printed letters and words have natural spaces between them, speech tends to have no such artificial division. For example: "Is it good?" often in spoken English comes out as, "Isitgood?" A recent device developed by the U of I group may help to ease the segmentation problem currently blocking advances to the development of a machine capable of obeying voice commands.

Dr. Murray L. Babcock, heading a group of the Biological Computer Laboratory researchers, working with Professor Von Foerster, is investigating the speech characterization concept by use of a Dynamic Signal Analyzer. This device was built for the U.S. Air Force and has a rapid signal response time over a 30 — 8000 cps range displayed in eight octaves, each of which contains 12 discrete frequency channels. It combines both continuous variable and discrete variable techniques in processing signals. By adding other specialized devices to the Dynamic Signal Analyzer, the Illinois engineers hope to characterize various phonetic elements in speech signals.

Although perfect recognition by machines of speech is still in the future, the U of I engineers through their research with the Signal Analyzer are advancing the day when phonetic speech recognition by machines will be an actuality. When that day arrives, programming of computers, voice-operated typewriters, and a host of other verbally controlled machines will be available to help ease the ever-pressing data and communications problems of the space age. ◆

NEW COORDINATED SCIENCE LABORATORY BUILDING

The first section of a six-stage building for the University of Illinois Coordinated Science Laboratory has just been completed and occupied by CSL researchers. The next five sections will be added as time and money permit. The first section now houses about 25 of CSL's 150-man staff.

Two major projects are under way in the new CSL structure. Both projects are supported by the National Aeronautics and Space Administration. One is a study of the upper atmosphere that will make use of rockets. Shots are slated late this spring to study the electron density in certain layers on the ionosphere. This project is directed by Prof. Sidney A. Bowhill of the Electrical Engineering Department and Howard W. Knoebel, research associate professor in the Aeronautical and Astronautical Engineering Department and in CSL.

The second project, which is under Knoebel's direction, is an attempt to determine the feasibility of using an electric vacuum gyroscope to make general relativity measurements in space. Both of these programs were reported in detail in the April 1963 issue of *Engineering Outlook*. ◆

ACADEMIC YEAR ELECTRONICS TECHNOLOGY INSTITUTE

Fifteen instructors from junior colleges and technical institutes will attend an Academic Year Institute for Electronics Technology Teachers starting this fall at the University of Illinois. This is the first Institute in this area of work to be sponsored by the National Science Foundation, and the first Academic Year Institute to be administered by the College of Engineering. The fifteen stipends will each amount to $3,000, with auxiliary funds of $450 per year per department, $75 per year for books, and up to $120 per year for travel. The program starts September 15 and runs through June 3, 1965.

The purpose of the Institute is to up-date the participants and provide subject matter competence. In addition to lab courses and seminars, there will be courses in basic electronic circuitry, differential equations applied to electronic systems, industrial electronics, and quantum mechanics in physics. Professor D. S. Babb of the Department of Electrical Engineering, the Associate Director of the program, is responsible for the coordination of subject matter.

The deadline for applications for the Electronics Technology Institute is May 1, 1964. Announcements will be made on May 10. Further information and application forms may be obtained from the Director of the Institute, Professor J. S. Dobrovolny, Head, Department of General Engineering, University of Illinois, Urbana. ◆

RADIOACTIVITY IN WATER, SEAFOODS, AND HUMAN BEINGS

Certain radioisotopes that have been found in natural watercourses have also been discovered in human beings. These cases have been found in areas where there has been a high concentration of fallout from nuclear testing. These radioactive materials could have been taken in by eating seafoods, or by eating grains irrigated with water from rivers which receive radioactive discharges. This discovery has stimulated a study in the University of Illinois Department of Civil Engineering on the fate of radioactivity entering such watercourses.

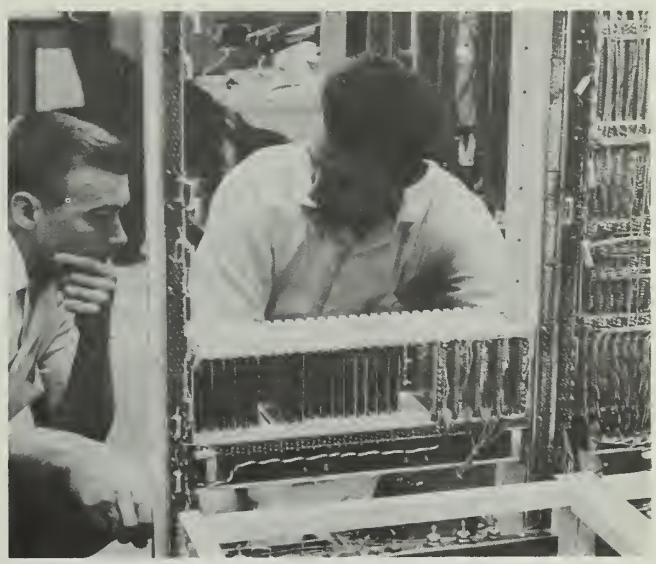
This study, which is under the direction of Professor J. T. O'Connor of the Sanitary Engineering Group, is specifically concerned with the behavior of radioactive forms of iron, zinc, and cobalt. These materials may come from fallout or from reactor operations. They may be found in rivers and streams, on muds and silts, or in the organisms that live in river beds. When discharged in the rivers, these metals leave the water rapidly, sinking into or onto the mud at the river's bottom. Here they are devoured by organisms that live in the bed, which are devoured by fish, which are devoured by humans.

While these quantities of radioisotopes are well within the limits accepted as "safe" by responsible public health authorities, a knowledge of the mechanisms of transport and the distribution patterns must be obtained for control and monitoring purposes. The work in progress, which is sponsored by the Atomic Energy Commission, entails several steps: the development of analytical techniques for monitoring natural waters for radioisotopes; a study of the precipitation or adsorption of these metals on river silts; a study of the effect of organic materials in releasing these metals from the bottom muds to the river water; a study of the uptake and concentration of the metals by underwater life; and a survey of the extent which these radioisotopes already exist in environmental samples of river water and mud taken near nuclear installations in the United States. ◆

JETS PROGRAMS FOR HIGH SCHOOL STUDENTS

The State of Illinois Junior Engineering Technical Society, with the cooperation of the faculties of three campuses, will sponsor three separate educational and orientation programs in engineering for high school students this coming summer. These programs, to be held at Bradley University in Peoria (July 26–August 8), the U of I Undergraduate Division in Chicago (July 30–August 14), and the U of I College of Engineering at Urbana (July 26–August 8), are in their third year. There will be no tuition fees, but charges will be made for room and board and for instructional supplies. Scholarships sponsored by engineering professional societies to cover these charges are available for some of the participants.

The deadline for applications is April 10, and appointments will be announced about May 1. All applications or requests for further information should be sent to State Headquarters, Junior Engineering Technical Society, 313 Transportation Building, University of Illinois, Urbana 61803 ◆



Also concerned with broins — electromechonicol rother thon biologicol — are these technicians in the University af Illinais Digitol Computer Laborotory. Here they ore checking one of the input-output channels of Illiac II, a new very-high-speed computer, the centrol port of which was completed in August, 1962. With a multiplying speed of 6.6 microseconds, this new machine serves os the University's fastest computing focility. It hos worked one foirly typicol scientific problem in physics obout 100 times faster thon the originol Illiac could have done.

U OF I GRANTS 49 PER CENT OF ILLINOIS DOCTORATES

In 1961–62 the University of Illinois granted 48.8 per cent of all doctoral degrees awarded by degree-conferring institutions in Illinois, according to a study recently published by the U.S. Office of Education. In the period studied, all institutions in the state granted 909 doctorate degrees; the largest number, 444, were awarded by the U of I. The second and third highest number of doctorates were granted by the University of Chicago (228) and Northwestern University (166). In total degrees, institutions of the state conferred 26,173 — with the U of I granting the largest number, 5,551 or 21.2 per cent. ◆

PEOPLE AND PLACES

W. L. Everitt, Dean of the University of Illinois College of Engineering, was elected Chairman of the Board of Directors of the Commission on Engineering Education in Washington, D. C., last month.

Professor Robert Hulsizer of the University of Illinois Physics Department has been honored for his outstanding contributions to physics teaching with the Distinguished Service Citation of the American Association of Physics Teachers.

G. R. Gurfinkel, a member of the faculty of the University of Illinois Civil Engineering Department, has been awarded a Danforth Teacher Grant. He is one of 50 recipients across the nation selected by the Danforth Foundation to receive the grants, which enable men or women already full-time faculty members to complete programs of graduate study.

J. P. Murtha, Associate Professor of Civil Engineering, was appointed Director of the Water Resources Center at the University of Illinois in February (see article in the December 1963 *Engineering Outlook*).

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 5, NO. 4, APRIL 1964

TRAFFIC ENGINEERING MANAGEMENT SCHOOL

As everyone knows, traffic engineering is an extremely big business today. Traffic engineers themselves have become aware of the need for more attention to the administrative management problems they are facing in their everyday work. Because of this a five-day institute on management principles has been scheduled at the Hott Memorial Center, Monticello, Illinois, May 10–15, 1964. It will be sponsored by the University of Illinois Highway Traffic Safety Center and the Midwest Section of the Institute of Traffic Engineers, in cooperation with the U of I Bureau of Business Management and Division of University Extension.

Subjects to be covered will include report writing, policy formulation, management of records, operations research and analysis, and administrative management. Anyone interested in obtaining further information and registration forms should write to Professor John E. Baerwald, 404 Civil Engineering Hall, University of Illinois, Urbana 61803. ◆

BACKSCATTERING MEASUREMENTS OF GAMMA RAYS

When a tennis ball is thrown against a wall its approximate rebound or deflection can be predicted. Likewise, if a high-speed bullet is ricocheted off a slanted hard surface, its general deflected path can be predetermined. If the bullet is traveling at a high velocity, however, some disintegration may occur, which complicates predictions. Civil engineers at the University of Illinois are facing a similar problem with the rebounding of gamma rays from concrete. In this case the rebounding is called backscattering.

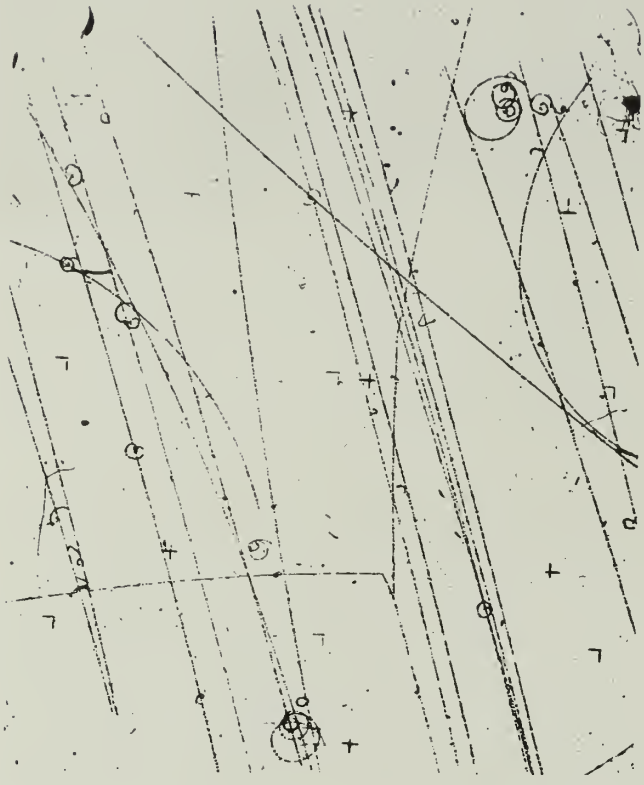
The basic studies concern a single source (or theoretically, a point source) of gamma rays released against an infinitely broad concrete surface and a detector reading backscattering intensities in exposure dose-rates. Variables have been introduced into the studies by changing the height of the gamma ray source above the scattering plane of concrete and also the distance of the detector from both the scattering plane and the source. Early research results have been made possible by programming this problem on the IBM 7094 computer to carry out detailed calculations which would otherwise require many years of hand calculations.

Results to date have verified and unified previously theoretical and experimental work. As the studies progress, new questions arise which are subject to solution by the computer techniques devised. For example, a variation on the basic studies concerns the change in answers to the backscattering problem if the scattering concrete surface is bounded instead of being infinite, thus opening the door to the solution of many practical problems. These studies are sponsored by the Office of Civil Defense and are expected to provide additional information on how a fallout radiation field is affected by the earth-air interface plane or by scattering surfaces of fallout shelters themselves. In addition, basic information is being obtained which will be of value in all aspects of radiation protection technology, in peace as well as war.

Gamma ray backscattering is only one of the subjects being studied within the nuclear radiation shielding program, which is under the direction of Professor A. B. Chilton, working jointly in the disciplines of nuclear and civil engineering. ◆

ENGINEERING SEMINARS AND DISCUSSIONS

The Engineering Calendar of Seminars, Symposia, and Discussions that was issued the week of March 16 listed 23 sessions open to the public. More than 50 per cent of the speakers at these meetings were from outside the State of Illinois, and four of them were from outside the United States. This gives some indication of the flavor of these technical sessions and their widespread interest. The *Calendar* listing these events is sent to many people not on the University of Illinois campus; if you are interested in obtaining a copy each week, free of charge, write to Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana 61803. ◆



Bubble chamber "events" similar to these are typical of those measured by the Scanning and Measuring Projector used by University of Illinois researchers in the field of particle physics.

BENCH MARKS IN PHYSICS

A bubble chamber is a device used for seeing where something that can't be seen was a moment ago. It is a vessel filled with liquid hydrogen that has been so highly superheated that an ionized subatomic particle moving through the liquid starts a violent boiling and thereby initiates the growth of a string of bubbles along the particle's path. These bubbles are photographed with specialized cameras, and the "data" resulting from the bubble activity is then ready for analysis. It is at this point that the particle physicist often finds his "data" bottleneck. Because it is possible to take thousands of bubble chamber photographs containing millions of points of possible interest to the researcher, present systems of scanning and measuring the pictures are frequently too slow. Already there is a mass of data from previous experiments that has not yet been interpreted.

At a University of Illinois physics laboratory a specialized device, a Scanning and Measuring Projector, is being used to speed up the analysis of bubble chamber data. Under the direction of Dr. Robert I. Hulsizer, one of the pioneer workers in its development, the SMP is capable of making both rapid and accurate measurements of bubble chamber and other photographs. One of these projectors, its human operator, and a high-speed digital computer work together to form a highly integrated team for interpreting much of the voluminous data that continues to accumulate in the rapidly expanding area of particle physics.

An invention of Dr. Luis W. Alvarez of the University of California, the SMP employs a unique method of operation. Tracks in a bubble chamber photograph are picked out by the human operator — this being one job that humans can still do better than computers — and points on the selected tracks are then located by the use of accurately positioned reference marks. These reference marks make it easier to locate a given point precisely. The SMP method is analogous to the use by surveyors of "bench marks" in mapping large pieces of terrain. With the SMP the photographic records are visually scanned by the operator at the same time as the measurements are being made by the apparatus. This serves as a double check to insure that the right tracks are being measured. The computer used with the SMP is immediately able to process, examine, and certify data generated by the SMP, and the computer's immediate feedback improves the reliability of the unit and reduces human error to a minimum.

The University of Illinois Physics Department presently has one of these units in operation and plans to construct two more with funds from the U.S. Atomic Energy Commission. ◆

STUDIES OF NEMATODES IN OUR WATER

Nematodes are partially transparent microscopic worms. Sometimes referred to as roundworms, they are a major branch of the metazoan family. They live in dusty air, on plants, in vegetables, in the soil, and in water. They enter water streams from both surface and subsurface watersheds, and in turn reach our reservoirs from these sources. Although much is known about them, broader and more substantial information must be developed about their behavior in different mediums under varying conditions to determine their reactions to environments, treatments, and controls. This work is being carried out under the direction of Drs. R. S. Engelbrecht and J. H. Austin in the Sanitary Engineering Laboratory at the University of Illinois. Dr. M. R. Matteson of the Department of Zoology is participating in this study.

Many interesting facts about nematodes have been established. They are of two types: free-living and parasitic. They may exist in the purest of our municipal water sources. They are difficult to filter out of water,

therefore making such a process expensive. Chlorination has relatively little effect upon the adult nematode and less upon the newborn eggs. They multiply rapidly in waste treatment plants. Possibly contrary to a normal assumption, their persistence tends to decrease at higher water temperatures. The current investigation is concerned with the free-living forms and means of removing them from our drinking water.

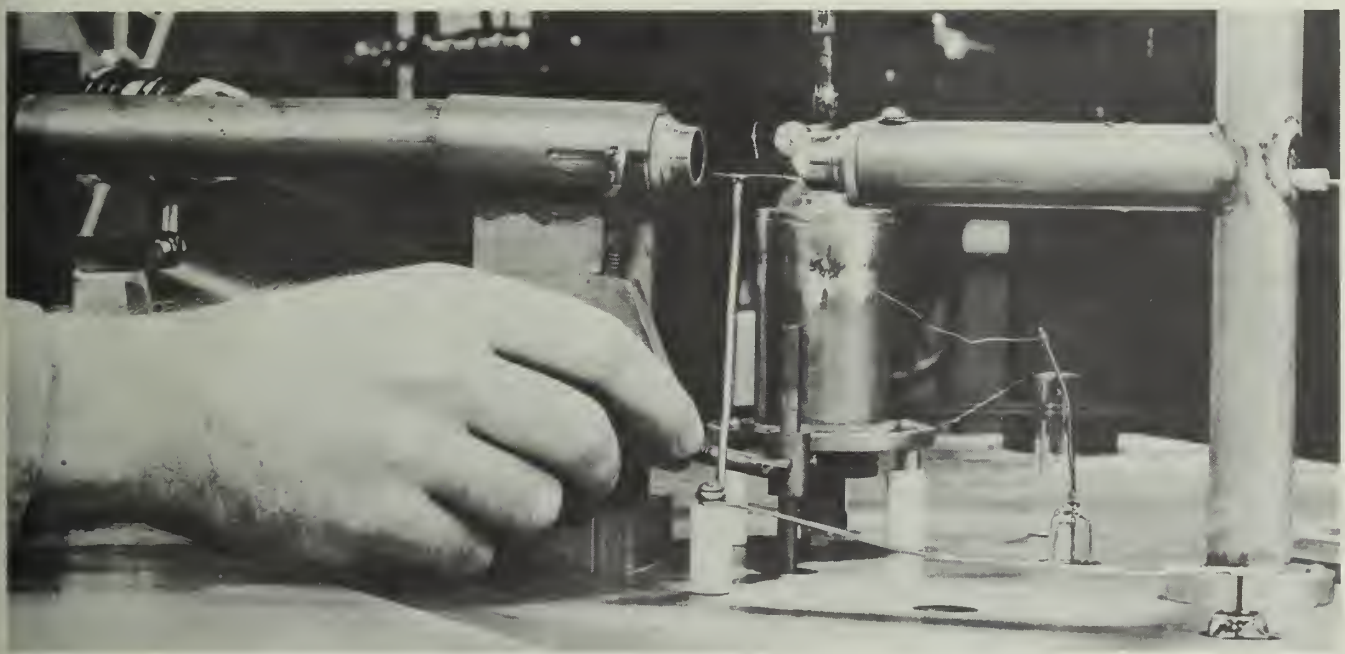
It is essential that we have high-quality water in our lakes, rivers, reservoirs, and municipal systems both for industrial and human use. Our nation has the materials and engineering talents to achieve this goal, and one step is the eradication of the nematode or any other related potential disease carrier. Research will be continued until substantial answers can be given on all aspects of their control. ◆

IT ALSO DISPLAYS THE TOWN NAME

Essential to any community is a good supply of water, both for household and industrial use. Though it is possible to pump water directly from the purification plant to the user, it has been found far more satisfactory and economical to store water in tanks, thus assuring an adequate supply of water during peak demand, and providing a source of water for emergency use. Water towers must be able to support the weight of the water, resist natural forces such as earthquakes and storms, and yet be as inexpensive to build as engineering know-how can make them. In recent years the free-standing water tower has become very popular. The lower part of this familiar structure is essentially a large diameter, thin-walled tube.

The behavior of such thin-walled tubes with various kinds of stiffening has been the subject of research carried out by the University of Illinois Civil Engineering Department in cooperation with the Chicago Bridge and Iron Company. The study in progress is the latest in a series undertaken with the help of assistantships which the Chicago Bridge and Iron Foundation has been sponsoring for twelve years. In addition to the application to water towers, the results of the present project will also be useful in the design of penstocks, the huge pipes used in hydroelectric installations to convey water to the turbines.

The project, which includes both experimental and analytical work, is a good example of the mutual benefits of university–industry cooperation. The Civil Engineering group was interested in greater understanding of the behavior of thin-walled tubular structures. The Chicago Bridge and Iron Company was interested in building safe and serviceable water towers and penstocks as economically as possible. The cooperative project is supplying answers for the questions posed by both groups. ◆



Electrical spraying af liquids may be praduced when the liquid emerges fram the tip af a hallaw, canducting capillary tube raised ta a high patential. The develapment and pragress af the spraying pracess are examined with the aid af high-speed phatamicragraphy. The capillary tube fram which the spray emerges is here seen suspended between the camera lens, left, and the light saurce, right. This phenamenan is currently under investigatian in the Charged Particle Research Labaratary af the Electrical Engineering Department at the University af Illinais.

Study of transport processes in gases is one of the research interests of the Department of Mechanical Engineering. Here, research assistant D. G. Barbee examines apparatus designed to study motion of a rarefied gas over a rotating disk. Experiments have been made in a vacuum to probe movement over the disks at 1 to 100 microns mercury.

PEOPLE AND PLACES

Dr. C. P. Siess, University of Illinois Professor of Civil Engineering, has been given the Henry C. Turner Medal of the American Concrete Institute "for notable research and committee service on structural members and fundamental properties of reinforced concrete."

C. C. Wiley, University of Illinois Professor of Highway Engineering, Emeritus, was the keynote speaker at the 50th Annual Illinois Highway Engineering Conference held on the U of I campus in March. Prof. Wiley retired in 1952 after 46 years of outstanding work at the University.

J. T. Tykociner, University of Illinois Professor of Electrical Engineering, Emeritus, has been honored by the Institute of Electrical and Electronics Engineers with election to the grade of Fellow. Cited for "his pioneering contributions to radio science," Tykociner is well known for inventing sound-on-film motion pictures, his work with radio and antenna development, and his still-active program of formulating a science of research (see *Engineering Outlook,* February 1964).

J. B. Voorhees, a senior in civil engineering at the University of Illinois, received the 1964 Bausch and Lomb Photogrammetric Award for Undergraduates during the 30th Annual Meeting of the American Society of Photogrammetry being held in Washington, D.C., March 17-20.

Professor G. M. Almy has been named Head of the Department of Physics. He succeeds Professor Frederick Seitz, who has been appointed Dean of the Graduate College and Vice President for Research at the University of Illinois.

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AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 5, NO. 5, MAY 1964

LOOKING INTO SOLIDS WITH A COMPUTER

Whether a solid is stretched, squeezed, or strained, engineers refer to the behavior of most material as linear until the stresses become so severe that the material fails; beyond that point the behavior is generally called non-linear. Non-linear behavior of a large mass of solid is difficult to describe or predict because there are very few mathematical solutions for problems related to it. A group of researchers in the University of Illinois Department of Civil Engineering are working with non-linear theories, using a 7094 computer to simulate a given material and what happens to it under conditions of unusual stress.

The group, directed by Dr. Alfredo Ang, works with problems that are extremely complex because non-linear theories are not easily adaptable to an analytical treatment. Problems that would take many man-years of manual calculations are solved on the computer in minutes. The researchers program the computer to simulate the material in which they are interested. A particular problem in which the group is involved is to simulate a blast at or near the surface of the earth, and to calculate the pressures at various points inside the ground. The effect of the blast that penetrates the solid material is in the form of stress waves, which are very much like the ripples that appear on the surface of a pond when a stone is tossed in. They move outward away from the disturbance, becoming weaker as they move further away. The solutions sought by the Civil Engineering group give numerical values to the pressures and motions created inside the solid at various distances from the point of shock.

Although Dr. Ang and his colleagues are not currently interested in design problems, it is obvious that the ability to predict pressures at certain depths can be an invaluable aid to eventually predicting the thickness of material necessary to resist an anticipated blast load. Given the make-up of the wall you want to stand behind, the size of the blast to be set off some distance away, and a few seconds of computer time, these gentlemen can determine how thick the wall will have to be to protect you. It may be that you are not interested in this precise problem, but a number of people in Washington certainly are; the work is being supported by the National Science Foundation and the Department of Defense. ◆

INTELLIGENT MACHINES

As a reader of these printed words you are utilizing many of the attributes of intelligence. In fact, considered abstractly, your very existence and presence in the world is considered evidence that organic intelligent systems are possible. What now remains is to demonstrate that synthetic systems — machines — having similar and analogous attributes are possible.

The Biological Computer Laboratory of the University of Illinois Electrical Engineering Department is attempting just such demonstrations. Specifically, the staff of this laboratory is interested in research on machines which exhibit such behavior as "curiosity" about their environment with resultant "adaptation" to that environment, "learning" of their past experiences with appropriate and consistent association of those experiences to form concepts, "self-awareness" — i.e., recognition of themselves and their surroundings, "goal-seeking" with the resulting avoidance of dilemmas, and perhaps "free-will" with its implication of unpredictability. These characteristics are some of those which are usually associated with intelligent behavior.

Such machines will need many functional sections which, when assembled into the complete system, augment each other to provide the desired behavior. For example, such machines will require "thinking units" which perform various computations and calculations such as recognition, comparison, and decision making. They will require connections with the outside world — that is, they will be able to "feel," to "see," to "hear" and to respond as our muscles do in order to interact with their environment. In the December 1960 *Outlook,* the Numa-Rete, which was built in the Biological Computer Laboratory,

Dr. Babcock is shown here making a voice recording for his study of the invariants of human speech. In the background and to the left is the frequency analyzer.

was described. This device could function as an "eye" for the proposed "intelligent machines." In the same article, another creation of the group was discussed — the "artificial neuron." This could serve as the "thinking units" of the machines since it has been demonstrated that networks of these artificial neurons can be trained, i.e., learn to recognize size and shape of objects, and can be autonomous, that is free-willed, etc. Still another functional unit of the proposed machines — the hearing organ — is now under study.

Professor M. L. Babcock is attempting to analyze speech signals with the ultimate goal of making an organ of hearing for intelligent machines. The analysis of speech has been under study for many years, but very little success has been achieved. Many reasons for the lack of success probably exist, among them being the sheer complexity of the speech signal. Tremendous variety and richness exists in the sounds of the vowels, semi-vowels, and consonants as spoken by an individual. The same sounds uttered by various people add tremendously to the complexity of the speech signal and complicates the task of any machine which must be devised to recognize such signals, especially when the large vocabulary of words required for communicating ideas is considered.

Professor Babcock is looking at speech and trying to find what he calls "invariants," certain characteristics of sounds and words which do not change with the accent, volume, or speed of the speaker. He feels that these invariants are located in the regions of a word where a transition takes place, as occurs when the speaker changes from a vowel to a consonant sound, or from a consonant to a vowel sound. In order to study such sounds he has supervised the design and construction of a machine called the frequency analyzer. With this machine Dr. Babcock is examining ninety-six frequencies to see if he can find the invariants of speech which make it possible for one person to communicate with another.

When various members of the research team make voice recordings with the frequency analyzer, "pictures" of the words are made on photosensitive paper by beams of light that are controlled electronically by the voice signals. The printed record of the words spoken will contain a number of wavy lines that represent various frequency ranges in cycles per second. These records are analyzed in an effort to find the invariants.

As has been found so many times before in the research projects of this group, the hurdles that stand in the way of building a successful "intelligent machine" or of achieving successful man–machine communications is not a lack of ability to design and build exotic hardware, but rather an inability to understand sufficiently how seemingly simple processes like hearing, understanding, and learning actually work. The uses for an intelligent machine that could understand human speech could be legion, but, as Dr. Babcock points out, "we will not be able to make a machine hear and react to words until we more fully understand how the human can interpret such sounds. We are not interested in copying the mechanisms used by man to accomplish this feat; but we are certainly going to have to have a good understanding of the processes and techniques involved in human-to-human speech recognition before we can bring about vocal communication between man and machine." ◆

PROTECTIVE CONSTRUCTION INSTITUTE IN JULY

The University of Illinois Department of Civil Engineering will conduct a six-week institute on protective construction beginning on July 6, 1964, under the auspices of the U.S. Office of Civil Defense.

This institute is one of several similar courses sponsored by the Department of Defense to increase engineers' and architects' abilities to design structures to resist nuclear weapons' effects. This particular course will cover both radiation and blast protection. It is designed for structural engineers who already have a basic competence in fallout shielding analysis methodology. It is offered with the objective not only of presenting current design concepts, but also of preparing the participants to keep abreast of future developments. Consequently, emphasis

will be placed on fundamental concepts as well as on applications.

Consistent with the broad objective of the Office of Civil Defense to develop a nationwide competence in the field of protective construction, priority for admission to this institute is being given to architectural and engineering faculty members who can include the subject matter covered by the institute in the educational programs of their respective institutions. If space is available, practicing architects and engineers who meet the prerequisites for admission will also be accepted.

There will be no fee or charge for college teachers of engineering who attend this course. Each faculty participant will be required to submit a report within 30 days after completing the course containing an analysis of the course, recommended improvements in subject materials, and curricular outlines and materials based upon the training received which would be suitable for use by his department or school. Faculty participants will be reimbursed at the rate of $125 per week for expenses plus a travel allowance (for a U.S. citizen living outside the country, the fare will be calculated from the U.S. port of entry nearest his present domicile). Practicing engineers and architects who attend the course will not be assessed a fee, but they will be expected to defray their own expenses. ◆

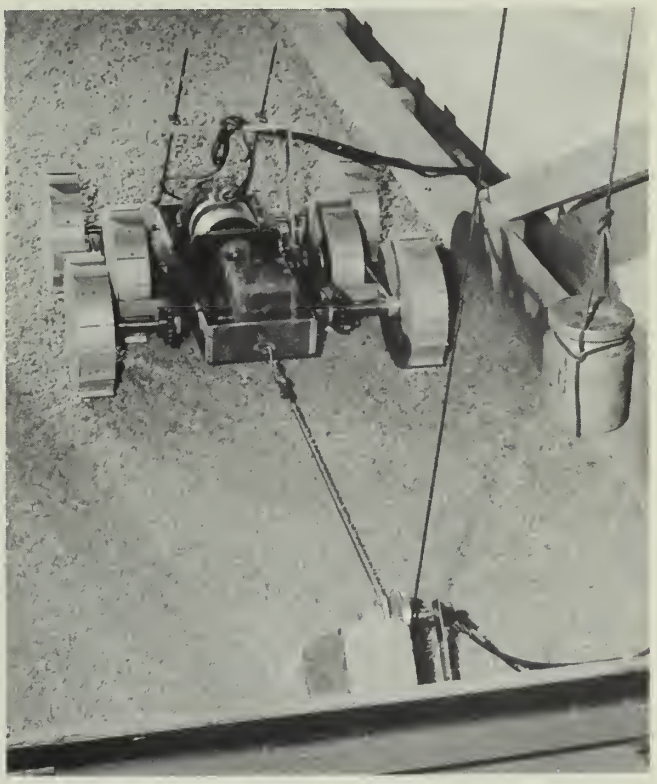
VEHICLE PERFORMANCE ON THE MOON'S SURFACE

How would an automobile behave when driven on the moon? Would it accelerate, brake, and climb hills just as it does on the earth? Vehicles for moon transportation must be designed with sufficient knowledge of the conditions under which they are to perform to be certain they will function properly in their environment. One big difference in the environments of the earth and moon is gravity. A study of how gravity affects vehicle behavior was recently completed by Professor G. A. Costello, University of Illinois Theoretical and Applied Mechanics Department, in cooperation with former T & AM staff member Dr. D. L. Dewhirst, staff engineer, Defense Operations Division of Chrysler Corporation. The purpose was to find how an earth-made vehicle would tow, accelerate, bulldoze, and climb hills if put on the moon.

Simulation of the moon's gravity has previously been accomplished by a platform dropped with a particular acceleration. However, a test of this nature must be of short duration, because a falling platform naturally covers a great distance in a short time. Also measurement problems are inherent in such set-ups. For these reasons Professor Costello used a different approach. He determined the effects of gravity by employing dimensional analysis, a mathematical method based on the premise that an equation which describes a phenomenon must be a dimensionally correct one.

The problem was formulated, using dimensional analysis, in terms of dimensionless parameters. The acceleration due to gravity, g, was contained in one of the dimensionless parameters and, hence, the effect of gravity was determined by varying some other controlled variable in this dimensionless parameter. The vehicle test results were accomplished by a six-wheel model made to run in a ¼-inch gravel bed, a non-viscous, cohesionless type of soil believed to be similar to moon turf. As the model ran, test data were taken. Then, by integrating the dimensional analysis with the test data, a relationship was found involving the ratio of drawbar pull to weight, the per cent slip of the model in the gravel, and g.

The ratio of drawbar pull to weight is essentially independent of gravity for a given per cent slip. From this conclusion a general statement can be made: the ability of the vehicle to accelerate, tow, and bulldoze on the moon would be reduced by a factor of six (moon gravity is ⅙ earth gravity), while the ability of the vehicle to climb a hill would be unaffected. ◆



A six-wheeled model of o vehicle to be used on the moon's surfoce is shown being tested in o test bin in the Deportment of Theoreticol and Applied Mechonics. The moterial in the bin is believed to be similor to thot which will be found on the lunor surfoce.

A ROCKET INTO THE IONOSPHERE

In April a payload designed at the University of Illinois rode a Nike Apache rocket 100 miles into the sky from Wallops Island, Virginia. It was sent up to learn more about how solar radiation causes the various layers in the ionosphere to form. The firing was part of the U.S. program for the International Quiet Sun Years of 1963–64, and was sponsored by the National Aeronautics and Space Administration.

The equipment, which was designed in the Coordinated Science Laboratory and the Electrical Engineering Department and built by the Geophysics Corporation of America, measured various properties of the D and E regions of the ionosphere (from 40 to 100 miles up). These properties, the electron and ion density and the amount of ultra-violet radiation, were measured by radio propagation from the rocket and reflection soundings from the ground.

The ionization in these regions limits the useful range of broadcast transmitters by absorbing the radio waves. At night there is no ionization in these lower regions, which explains why radio stations from long distances away are more often heard at night than during the day. It also shows why a radio station with a powerful transmitter such as the University's WILL station (5,000 watts) is required to stop A.M. transmission at sundown every day. If it were not, it would interfere with the reception of other stations on the same frequency outside its normal daytime range.

A great deal more needs to be understood about the ionosphere's density, its relation to solar radiation, and its effects on radio broadcasting. The April rocket firing was the first in a series of seven soundings this year which will be made at predetermined seasons and times of day. The next series of launchings will be in July.

The radio propagation experiment was directed by Professor Howard Knoebel of the Coordinated Science Laboratory. The partial reflection sounding experiments were directed by Professor Sidney Bowhill of Electrical Engineering. Other experimental phases were under the direction of the Geophysics Corporation of America, and Professor Bowhill was the technical director for the entire program. ◆

PEOPLE AND PLACES

Professor C. Dale Greffe, University of Illinois Department of Mechanical and Industrial Engineering, has been elected vice president of the new Illinois Association of Professions, which includes medicine, dentistry, law, architecture, pharmacy, engineering, and veterinary medicine.

Professor M. A. Sozen of the University of Illinois Department of Civil Engineering went to Anchorage, Alaska, in April to study earthquake damage.

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LEONARD COBURN
119 C.E.H.
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VOL. 5, NO. 6, JUNE 1964

NEW KNOWLEDGE FROM THE IONOSPHERE

The existence of an ionospheric phenomenon known as the "Z-trace" has been verified at the University of Illinois in a study of records made by a rocket shot last April. The Z-trace had been noted previously but not understood. Evidence supporting existence of the trace and tentative support of a theory explaining it were the unexpected results of the project which was sponsored by the National Aeronautics and Space Administration.

The rocket, shot from Wallops Island, Virginia, carried instruments built by the University of Illinois Coordinated Science Laboratory for a research program under Professor Sidney Bowhill of the University's Department of Electrical Engineering. It reached an altitude of 105 miles. The records show that at 95 miles the 3-megacycle radio signal directed to it had faded out due to bending of the signal by the ionosphere, but that above this zone the signal resumed.

Bending of radio signals by the ionosphere is a well-known phenomenon, important to long-distance radio communications. Records made by the rocket show the signal refracted, or bent, until it was headed back toward earth. But they also indicate that after the rocket passed through the refractive layer, signals were again received. Professor Bowhill says these were not signals which had passed through the ionosphere, but were the Z-trace, a companion signal created in the ionosphere by a previously suggested "coupling effect." This coupling may be compared to action in an electrical transformer where passage of one current generates a second, though there is an insulating barrier between the two.

Preliminary examination of the rocket records at the University of Illinois also revealed the success of two new ideas which were built into the instruments under direction of Professor Howard Knoebel of the Coordinated Science Laboratory.

One was the use of an electrical instead of mechanical "spin" for the signal used to measure electron density in the ionosphere. In other experiments spin has been obtained from the turning of the rocket, rotating on its axis six times per second during flight. The U of I instruments electrically created a spin of 250 revolutions per second, which permitted the measurement of electron density with much greater detail.

The second new idea involved a servo-loop circuit in which the returning signal from the rocket automatically kept the strength of the outbound signal constant as received by the rocket. Measurement of the increase necessary to do this provided a much more precise record than other methods.

In addition to the radio propagation experiment, the rocket also carried instruments for other measurements of ionospheric properties. These included a plasma probe measuring ion density and electron temperature, photometers measuring intensity of ultraviolet light, and a device to measure atmospheric pressure. Additional measurements were made from ground radio sounders of the ionospheric electron density both during the rocket flight and on preceding days. Though the rocket was in the ionosphere only 5 minutes during its 7-minute trip from earth and back, the extensive records will take months of data processing and analysis to extract the wealth of scientific information they contain. ◆

ENGINEERING DEPARTMENTAL REPORTS AND THESES, 1963

This new publication contains bibliographic data and abstracts of research reports published by departments in the University of Illinois College of Engineering during the 1962–63 fiscal year. The bibliography provides information about papers written by the research staff which may not be available except as departmental publications. Titles, authors, and advisors are presented for master's theses and doctoral dissertations.

Engineering Departmental Reports and Theses, 1963, Engineering Experiment Station Circular 82, is available free of charge from the Engineering Publications Office, University of Illinois, Urbana 61803. ◆

A CASE OF MEASLES IN THE FOUNDRY

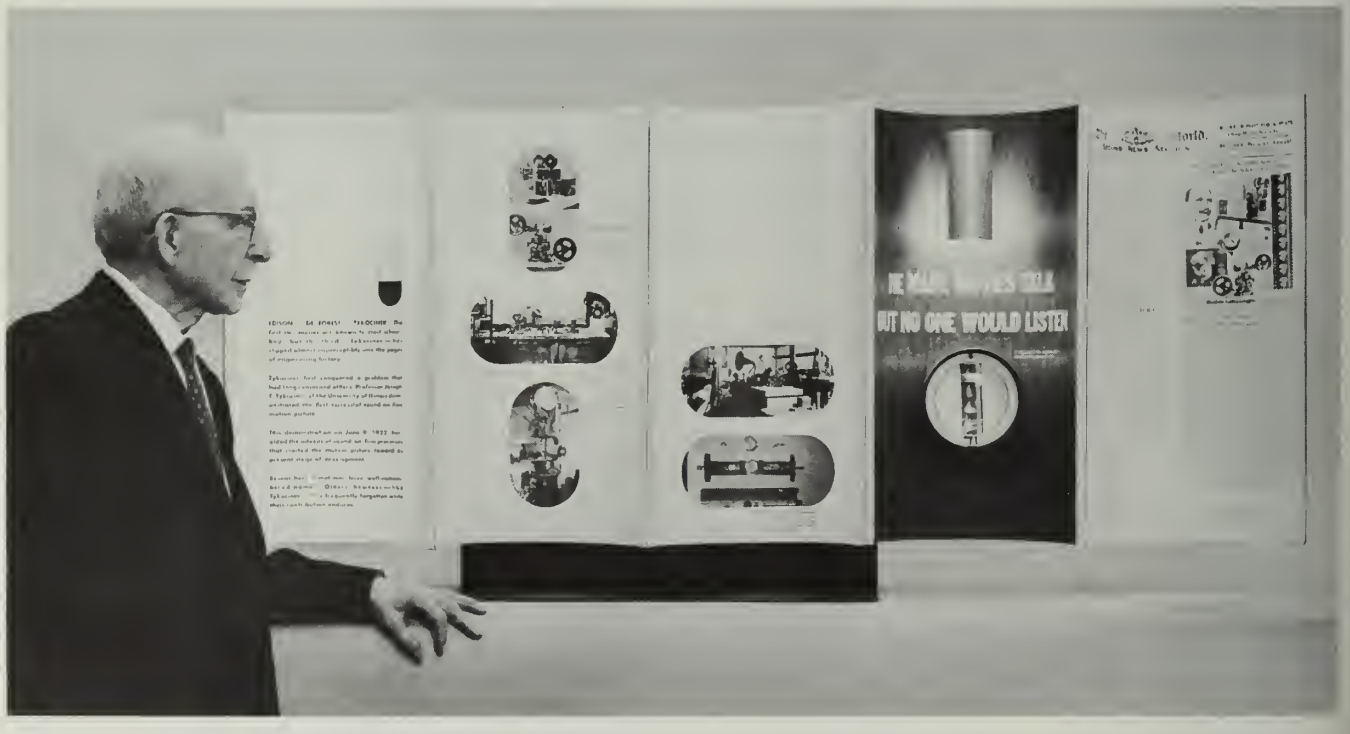
One of the best ways to produce high-precision metal castings is to use ceramic molds. Such molds permit the production of parts with very close tolerances, but a few of the alloys used, particularly those containing a certain amount of chromium, produce castings that have "measles." Measles are shallow depressions that occur as spots on the surface of the metal which, although not deep, cannot be tolerated in precision parts. A group of researchers in the University of Illinois Department of Ceramic Engineering is studying the problem and looking for possible solutions.

The ceramic molds consist of fine-grained refractory oxides which are initially mixed with a hydrolyzed ethyl-silicate-alcohol solution. This provides a fluid mixture which can readily be formed and then gelled by the addition of ammonia or other basic chemicals. The gelled mold is then ignited, which burns the alcohol off and develops a microcrazed structure. The minute cracks are important because they provide dimensional stability and provide a structure that can better resist the thermal stresses which result when molten metal at 3000°F is poured into the mold. Preparation of the mold in this manner is known as the Shaw Process.

The study, which is entering its second year under the direction of Professor J. A. Nelson, strongly indicates that the principal reaction related to measles is selective oxidation of the metal after it has been cast and while it is cooling in the mold. Evidence substantiating this theory has been obtained by extensive studies of the oxidation characteristics of the alloys commonly cast by this method. The highest incidence of measles has been related to certain alloys which show the highest oxidation rates.

The oxidation of the metal in itself is sufficient to bring about small depressions in the metal surface. But the oxides of the metal may be molten at casting temperatures and this accounts for their observed permeation into the ceramic mold. The degree to which this affects surface irregularities and the reason for selective oxidation at localized sites will be the object of further research.

The Shaw Casting Process is also being studied in the Mechanical Engineering Department Foundry. This investigation, which is being directed by Professor James Leach of the Mechanical Engineering Department, may contribute further to the analysis of the interfacial reactions by bringing forth more information on time-temperature relationships in the casting process. Such cooperation between the two departments and the Arnet-Shaw Corporation promises a cure for measles in the foundry. ◆



Professar Jaseph T. Tykaciner, who invented and first publicly demanstrated saund-an-film mavies in 1922 at the University af Illinais, views exhibit prepared by the Callege af Engineering ta tell the stary. One such exhibit has been presented ta the Fard Museum in Michigan and its twin is being displayed an the University campus at Urbana-Champaign. Display panels include a partion af the ariginal film with variable-density saund track under a magnifying glass, pictures af the inventar's labaratary and equipment, and a page fram *The World* af July 30, 1922, reparting the inventian. The displays were prepared by Gerry Weltan of the Engineering Publicatians Office.

SEMICONDUCTOR INTEGRALS

In calculations of the effect of high frequency electric fields and steady uniform magnetic fields on the properties of metals and semiconductors, two integrals, $A(p,x)$ and $E(p,x)$, are of particular importance. In University of Illinois Engineering Experiment Station Circular 84, *A Tabulation of Some Semiconductor Integrals,* by Richard M. Brown and Norman K. Hindley, the two integrals are evaluated to greater accuracy than has previously been published and tabulated versus the square root of the argument at closer intervals than has been previously done. This tabulation is expected to be in a more convenient form for calculations involving experimental data.

The Circular includes fourteen pages of tabulation. It is available from the Engineering Publications Office, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois 61803, for one dollar. ◆

CONTRACTORS' COMPUTER CUTS CONSTRUCTION COSTS

Flipping a coin is not a means of making a decision; it is a means of not making a decision. Yet this "heads or tails" system is sometimes used by the contractor faced with the awesome number of possibilities involved in construction jobs. He more often attempts to base his decisions on his past experience, but a man does not have the ability to remember or to choose between the hundreds of possible answers he knows or recalls as tentative solutions. This is a job that a computer, properly programmed, can do for him. The Civil Engineering System Laboratory (CESL) at the University of Illinois is based upon this idea.

CESL, which is sponsored by the Central Illinois Builders of the Associated General Contractors of America, the Building Construction Employers' Association of Chicago, and a number of individual companies, has devised programs for its IBM 1620 computer to solve problems in job planning, business applications, productivity forecasts, and production analysis. These programs or the computer itself may be used by contractors, but the main purpose of CESL is to develop new means of using computers for decision making, cost reporting, cost control, and estimating. These studies are generally dedicated to finding systems for scheduling, planning, and the selection of men, materials, and equipment that will allow the contractor to perform his work with maximum efficiency and profit.

The research of CESL which is done for the construction industry is evaluated by an Advisory Board made up of representatives of the organizations and firms that sponsor the lab. Professor L. R. Shaffer of the Civil

Professar L. R. Shaffer, head af the Canstructian Engineering Group, reads the cansale af the IBM 1620 camputer while Mrs. Nancy Gnilka, secretary and keypunch aperatar far the Civil Engineering Systems Labaratary, types instructians far a pragram.

Engineering Department, who is the manager of CESL, is chairman of the Board. The Committee on Computer Use, which is chaired by Professor S. J. Fenves, has general administrative responsibility for CESL. The research activities of CESL are closely allied with the current direction of the educational program of the Construction Engineering Division (see *Outlook,* December 1960) which is also headed by Professor Shaffer. This program is designed to furnish graduates who are familiar with the problems inherent in construction engineering and the means of solving them, particularly by use of the computer.

Both the educational and research programs in this field at the University of Illinois offer alternatives to the haphazard "heads or tails" system of (not) making decisions. They are designed to cut costs for the contractor by making his business more of a science and less of a gamble. ◆

FAILURES FROM TEMPERATURE DIFFERENCES

Nuclear reactors, leading wing edges of supersonic airplanes, rocket exhaust tubes, and space vehicles reentering the atmosphere all have one thing in common: extreme temperature differences in their structural members. When a portion of a solid member becomes hotter than its surrounding material, the hotter material attempts to expand but is restricted from doing so by the cooler material. This temperature difference, if severe enough, can cause cracking and failure of the structural member.

Ronald B. Carr, instructor and research associate in the University of Illinois Department of Theoretical and

Applied Mechanics, is currently making a study of conical shells subjected to such extreme temperature differences. The investigation consists of an analytical study of the problem and an attempt to verify by experiment the values obtained analytically. The experimental portion consists of heating an aluminum conical shell to a uniform temperature and then submerging it suddenly in a flowing stream of water, which makes the outer shell surface much cooler than the inner surface. By recording strains and temperature on the inner surface, the validity of the analytical solution is determined.

This study thus promises to add further knowledge to the behavior of material undergoing extreme and non-uniform temperature changes, perhaps resulting in design of structures that will better resist failure due to these temperature gradients. ◆

PEOPLE AND PLACES

Professor Kazuhiko Nishijima of the University of Illinois Physics Department has been awarded a prize by the Japan Academy for his distinguished contributions to research in theoretical physics, particularly for his contributions to the so-called "strangeness" theory of elementary particles. The award was made on May 8 in Tokyo at the Japan Academy, with the Japanese emperor in attendance.

Professor W. R. Ashby, University of Illinois Department of Electrical Engineering, and **Professor D. D. Perlmutter,** Department of Chemical Engineering, have received fellowships for 1964 from the Guggenheim Foundation.

University of Illinois winners of four of the 1964 awards for scholarship, research, student activities, and achievements in the social sciences and humanities have just been announced: **J. A. Johnson,** Williamsville, N. Y., physics, the Lisle Abbott Rose Award; **P. R. Bruggink,** Markham, Ill., chemical engineering, the Hamilton Watch Award; **G. Mesri,** Tahriz, Iran, civil engineering, the Honeywell Award; and **D. L. Steele,** Normal, Ill., physics, the Harvey H. Jordan Award.

Professor A. W. Allen, University of Illinois Department of Ceramic Engineering, has been elected to a four-year term as a trustee of the American Ceramic Society.

Dr. W. L. Everitt, Dean of the College of Engineering, and **Dr. N. M. Newmark,** Head of the Department of Civil Engineering at the University of Illinois, are members of a twenty-five-man committee to draw up plans for a National Academy of Engineering.

Dr. H. L. Langhaar, University of Illinois Professor of Theoretical and Applied Mechanics, has been named a Fellow by the Council of the American Society of Mechanical Engineering.

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RESEARCH
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In the order listed, this issue contains articles on the following subjects:

SOMETHING NEW IN ENGINEERING EDUCATION

The University of Illinois and the University of Colorado have embarked upon a cooperative program unprecedented in American engineering education. The idea behind the program is to use the strengths of each institution to help develop the potential strengths of the other. If successful, this approach can be used in the development of a number of centers of excellence in engineering education across the country.

The program is sponsored by the Commission on Engineering Education and financed by a $200,000 grant to the Commission from the Charles F. Kettering Foundation. It is called "Project BUILD," which is short for "Bi-University Institutional Liaison for Development."

Under the BUILD program, Illinois and Colorado will exchange senior faculty members for research and teaching at both undergraduate and graduate levels, and will join in cooperative research programs utilizing unique facilities of each institution.

They are planning an exchange program under which graduate students, while remaining enrolled in one institution, may go to the other for specific courses. Plans also are being made for joint conferences and seminars in engineering research and education.

Illinois and Colorado were picked for the first program because of a number of common areas of demonstrated strength and great potential and because there already are close ties between the two institutions. M. S. Peters, U of C Dean of Engineering, formerly headed chemical engineering at Illinois, and President Joseph R. Smiley of Colorado was dean of the College of Liberal Arts and Sciences and of the Graduate College at Illinois before going to his present post.

Project BUILD is headed by a four-man committee with Professor Klaus D. Timmerhaus, Associate Dean, U of C College of Engineering, an Illinois alumnus, as chairman. Others are Professor Robert D. Williams, Assistant Dean at Colorado; Professor Mac E. Van Valkenburg, Associate Director, Coordinated Science Laboratory at Illinois; and John J. Desmond, Assistant Director, University of Illinois Engineering Experiment Station. ◆

NOT WITH A BANG BUT A CHIRP

"Bangs" and "chirps" are common topics of discussion in the field of pulse compression radar — but no one ever hears them. These are names for radar pulses: bangs are short, high-powered radio signals; chirps are longer signals which change from low frequency at one end to high frequency at the other, carrying large amounts of energy within their greater lengths. The pulse compression technique simply sends out chirps instead of bangs as radar signals. When a reflected chirp returns it is compressed in a novel way: within the receiver amplifier the high-frequency back end of the pulse travels faster than the low-frequency front end, telescoping the chirp into a synthetic bang.

This system was first proposed during World War II as a means of getting greater power and range from the primitive equipment then in use, without sacrificing the detailed information that short signals produce. After attempts by others, Bell Laboratories developed a workable system. Since then, pulse compression has found wide use in radar installations.

Now chirps are being put to a different use — exploring the atmosphere. Under the direction of Professor Sidney A. Bowhill, two members of the Aeronomy Group of the University of Illinois Department of Electrical Engineering, Theodore Rzeszewski and Donald Wipperman, are building a modified version of this high-powered radar to detect the various levels of the ionosphere that help and hinder long-range radio communications. Theirs will be the first pulse compression sounding device ever built, and hopefully will enable them to detect the radio-reflective layer of the ionosphere during those frustrating times when it effectively "disappears" from conventional equipment. ◆

COORDINATOR FOR INDUSTRY RELATIONS APPOINTED

Marvin E. Krasnow, formerly Director of Research and Development for the Hallicrafters Company in Chicago, has been appointed Coordinator for Industry Relations for the University of Illinois College of Engineering. The appointment was announced by Station Director Ross J. Martin.

Martin said Krasnow's new duties will involve all phases of work related to the College's continually increasing industry relations interests. One of his specific assignments, according to Martin, will be assisting in the development of the Midwest Electronics Research Center (*Outlook,* September 1963) and the Production Engineering Educational and Research Center (*Outlook,* October 1963). Martin said "the addition of Dr. Krasnow to our staff reflects our growing interests in working with industry and in promoting the industrial growth of Illinois and the Midwest generally. He brings us the ability and experience we need to make real strides in this activity."

Krasnow holds a B.S. degree from Northwestern University and M.S. and Ph.D. degrees in chemistry from The Ohio State University. In his career he has been involved in many areas of science and engineering: research, teaching, and administration. He has been a member of the Board of Directors, Chicago Area Research and Development Council; the Governor's Committee on Research and Development in the State of Illinois; the Illinois State Board of Higher Education; and the Industrial Advisory Board of the National Electronics Conference. ◆

AN INTERCONTINENTAL RESEARCH TEAM

Advising students is not an unusual undertaking — unless, that is, the students are 6,000 miles away, and a letter takes two or three weeks to get from student to advisor. Professor J. C. Wheatley of the University of Illinois Physics Department is the advisor, and the students are seven doctoral candidates at the Institute of Physics in Bariloche, Argentina. The problem of 6,000 miles has been solved in a unique way by two radio stations: one in the Physics Building at Illinois and the other in Argentina. This radio setup provides not only instantaneous, but also clear and easily understandable communications.

Professor Wheatley first visited the Institute, operated by Argentina's Atomic Energy Commission, in 1961. It specializes in physics, with minor programs in mathematics, physical chemistry, physical metallurgy, and languages. The students enroll after two years of general university training and receive three and one-half years of technical training that provides an education up to the level of doctoral thesis work. The Institute is primarily associated with the University of Cuyo at Mendoza and accommodates about sixty students.

Now, through the cooperation of the National Science Foundation and the U of I, students also have the opportunity of doing doctoral thesis research in low-temperature physics. The research projects are mainly concerned with the thermal capacity and thermal resistance of materials which are studied at temperatures within one degree of absolute zero. This research is aimed at understanding the fundamental properties of matter. Since the facilities needed for the work are complex, using many specialized techniques from all fields of physics, this particular research is developing highly competent scientific personnel who are thoroughly familiar with the developments of modern technology.

The students in Argentina have been working on topics related to the work at Illinois since the project began in 1961. The radio setup, operated on this end by R. E. Sarwinski, a research assistant in the low-temperature physics group, provides a clear enough signal for them to discuss technical problems, results, and needs for additional equipment.

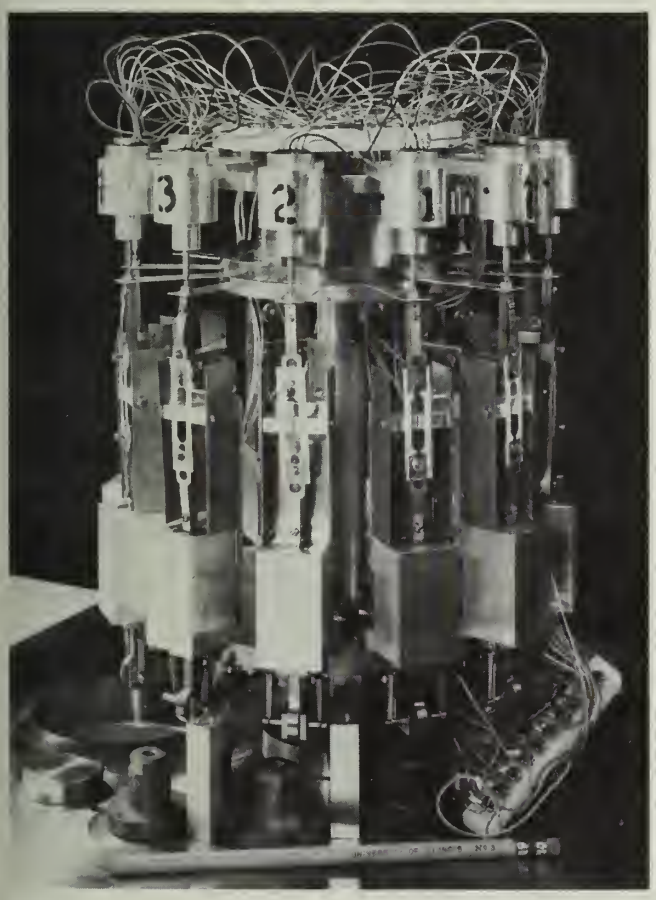
At present, most of these students will become teachers and researchers in Argentine universities, but Argentina has a progressive culture. As its industries begin to demand doctoral level personnel, an increasing number of advanced physicists will be employed.

Although seven doctoral candidates is a relatively small program, Argentina hopes that it is just a start. Already, the University of Chicago has started a similar program

concerning energy loss of charged particles in matter. It seems clear that even if educators in the United States are thousands of miles away from their students, they can give help and receive help at the same time. Such cooperative projects aid the developing country in raising its standard of living and in increasing its own research potential, while they also provide new people to aid the research staffs of American institutions — even though the advisor may never meet his advisees face to face. ◆

THE THEORETICAL STRENGTH OF GLASS FIBRES

Because of inherent structural defects, the theoretical strength of a material cannot usually be reached or, in fact, even approached. Most metals are between ten and thirty times weaker than theory predicts. But glasses, which are ordinarily as much as 100 times weaker, can approach to within a factor of two or three of the theoretical strength when made in the form of fibres. Unfortunately, the fibre surface is peculiarly susceptible to damage, and precautions have to be taken to minimize minor surface abrasions during fabrication processes.



Tests of tiny strands of gloss fibre in this mochine have come within o foctor of 2 of the theoreticol strength limits of such moteriol. In octual use, the device is housed in a bell jor which is evacuated prior to testing.

A study of the mechanical behavior of glass fibres has been under way for some years in the University of Illinois Department of Theoretical and Applied Mechanics as part of a U.S. Navy-sponsored project. Research Associate N. M. Cameron is currently making a study of the effect of very low ambient pressures on the fracture stress. For this investigation a vacuum system capable of attaining pressures as low as 10^{-6} mm. of mercury was built. This system contains twelve tensile testing machines within the vacuum chamber which enable loads of up to thirty grams to be applied to the specimens. These loads can be recorded to within 1 per cent accuracy.

The glass fibres that are tested are .00025 inches in diameter — approximately one-tenth the size of a human hair. They exhibit a substantially higher strength in vacuum than the 550,000 p.s.i. normally observed in the air (the latter strength is approximately five times higher than that of mild steel). This increase of strength in a vacuum is thought to be due in part to the removal of water molecules adsorbed to the glass surface and present in the immediate surroundings of the fibre, and also to the increase in surface tension of the material. The removal of water molecules reduces stress corrosion, and the higher surface tension increases the energy required to form fracture surfaces. Electron microscope studies, coupled with further mechanical behavior investigations, will shed more light on the surface condition of the fibres and perhaps give new clues on how to prevent surface damage during fabrication. The long-range goal of such investigations is the development of even stronger and less easily damaged fibrous glasses. ◆

TIRED BRIDGES

Have you ever wondered what happens to a bridge as thousands of vehicles pass over it day after day, year after year? With the passage of time more and more traffic with heavier loads use our bridges until such structures, unless properly designed, develop the old age disease, cracks in the joints. To protect against such failures the staff of the University of Illinois Civil Engineering Department has for many years been concerned with the development of design criteria for such structures.

The rapid development of new high-strength steels and the use of new fabrication processes require an understanding of the basic factors contributing to this type of failure, generally referred to as fatigue. Included among these factors are items such as the effect of fabrication details, residual stresses, applied stress cycles, properties of the base materials, and number of cyclic repetitions of loading.

The Bureau of Public Roads, because of its concern with

the Interstate Highway System, has for several years sponsored a program to develop such information. The program has included the entire range of available structural steels in rolled shapes as well as built-up welded girders. Splices, which are necessary in long structures, have received considerable attention because small changes in details can have a significant effect on their strength under repeated loads. The influence of stiffeners and their method of attachment are also of great importance, as are cover plates and transitions in flange thickness. In these latter cases the effect of geometry and stress concentrations are most significant.

A recent phase of this program has been concerned with the behavior of girders with extremely thin webs. Proper application of such girders could result in greater economy in the construction of highway bridges. The various projects at the University that are related to bridge design are directed by Professors W. H. Munse and J. E. Stallmeyer. Information obtained on this program is reflected in the current design specifications for bridges. As more information becomes available and greater consideration is given to traffic frequency and load distribution, the improvements which result will lead to safer, more attractive, and more economical bridges. ◆

PEOPLE AND PLACES

Professor H. H. Hilton, University of Illinois Department of Aeronautical and Astronautical Engineering, has been appointed a member of the National Academy of Sciences–National Research Council Committee on Basic Research.

Professor Thomas J. Dolan, Head of the Department of Theoretical and Applied Mechanics, and **Professor Kenneth J. Trigger,** Department of Mechanical and Industrial Engineering, have been elected as Fellows in the American Society of Mechanical Engineers.

Dean William L. Everitt, College of Engineering, has been elected chairman of the board of directors of the Commission on Engineering Education. The Commission is made up of a group of leaders from universities and industry who are deeply interested in the quality of engineering education and its advancement.

Alan Kingery, assistant editor for the University of Illinois College of Engineering from 1959 to 1962 and associate editor since 1963, was named Director of Engineering Publications at the beginning of the current academic year. He succeeds **Paul T. Bryant,** who has joined the faculty of Colorado State University as an assistant professor of English.

Dr. John Bardeen, University of Illinois physicist who in 1956 received the Nobel prize as co-inventor of the transistor, was awarded the Vincent Bendix award for outstanding research contributions by an engineering educator at the annual meeting of the American Society for Engineering Education.

Professor H. E. Carter, Acting Dean of the Graduate College and Head of the Department of Chemistry and Chemical Engineering at the University of Illinois, has been named by President Johnson to a six-year term on the National Science Board, governing board of the National Science Foundation.

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AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 5, NO. 8, OCTOBER 1964

In the order listed, this issue contains articles on the following subjects:

HAIRCUTS FOR HIGHWAYS: SHOULDER-LENGTH GRASS

Our nation's continually expanding highway network brings with it a problem motorists often overlook: thousands of acres of roadside grass to be mowed. Since highway shoulders are often steeply banked, mowing them can be very difficult. Made-over machinery is no longer adequate for this huge job, so research has been initiated which will help equipment designers create safer, more efficient roadside mowers.

An important part of this research was recently completed by the University of Illinois Agricultural Engineering Department. Research Associate R. L. Pershing made a detailed study of the behavior of tractors on roadside slopes, including the formulation of a mathematical model of tractor behavior which considered such variables as shoulder slope, tractor speed, tractor yaw and steer angles with reference to a horizontal "control line" on the face of the slope, and slip-resisting side force on the tractor. Field tests supplied necessary data for the model. Various tractor-mower units were driven on slopes up to 45 per cent which had been marked with steel tape control lines, while angular measurements of the tractor's position were made. Computer analyses of these measurements indicated possible changes in tractor design for better and safer mowing.

Hopefully this research will simplify the maintenance of roadside grass (now increasing at the rate of thirty acres per mile of new interstate highway), which makes highway travel safer and more pleasant. ◆

CAN THE BRAIN UNDERSTAND ITSELF?

No computer repairman could work without a circuit diagram — but a brain specialist must. His work is hampered because no one has yet been able to analyze the circuitry of the brain, the most complicated computer of all. Soon that may change. For the first time anywhere, researchers at the University of Illinois have succeeded in mapping in complete detail typical nerve circuitry of two structures within the brain of the cat. This fundamental step toward understanding the brain was announced by Professor William J. Fry of the Department of Electrical Engineering Biophysical Research Laboratory.

A team of experts in such varied fields as biophysics, neurology, and electrical engineering cooperated in this research. Their efforts have produced a laboratory with unmatched research facilities, including a custom-built, high-intensity ultrasonic irradiating system.

Two methods of investigation developed during the last decade at the Biophysical Research Laboratory provided the basis for this advance in knowledge. The first technique involves using ultra-high-frequency sound to produce changes in inner parts of the brain without damaging other components or interrupting the blood supply to any region. The second method, an essential part of brain circuit analysis, is the precise determination of nerve cell populations in both normal and modified brains. Cell groups, which often comprise only a small part of the total nerve population of a brain component, must be accurately counted and located in order to determine the brain's inter-cell "wiring."

Identifying nerve cells is a tedious job. From each specimen brain thousands of slices are mounted as microscope slides, portions of which are photographed, enlarged, and assembled into wall-size photomicrographs. From these "maps" the boundaries and individual cells of brain structures are labelled and measured, a process which may take six months for a single structure. Syn-

thesis of the data from these large cell maps takes the form of circuit diagrams. No other quantitative description of brain structure comparable to these drawings has ever been produced, but this precision has its price: thirty full-time staff members worked three and a half years to provide enough data for Professor Fry to analyze in order to derive the circuitry of tissues less than one-tenth the size of a pea.

The job of applying these methods of analysis to the human brain will be enormous. Since the human brain is ten thousand times as large as the amount of tissue already analyzed, the process of gathering data must be greatly accelerated if the task is to be completed in even a few lifetimes.

The value of this kind of analysis to medicine is incalculable. Surgical treatment of disorders of the central nervous system will largely be replaced by safer, more specific treatments. Physical changes related to emotional phenomena may be traced with much greater accuracy, and means of exploiting the vast potentialities of the brain may be discovered. Designers of computers and other sophisticated electronic devices may find clues in the circuitry of the brain for building improved machines with such spectacular abilities as self-awareness and self-repair. And man's most fascinating puzzle — himself — will be a great step closer to solution. ◆

THE GRASS *IS* GREENER

Does it pay a young man to change jobs? The answer, from a study of engineers who were graduated from the University of Illinois five years ago, appears to be "yes."

Mrs. Pauline Chapman, placement officer, U of I College of Engineering, gathered and analyzed information from 423 graduates of 1959, 66 per cent of the total class. Two hundred and forty engineering graduates still with their first employers now average $814 a month; 119 who made one job change, $841; fifty who made two, $812; ten who made three, $894; and four who made four or more changes, $882.

Eighty-three graduates are in the aircraft and missile industries, averaging $880 a month salary, and seventy-one in electronics, averaging $879. Highest average pay is $973 reported by six in the food industry, followed by $961 for seven in construction and building materials.

In 1959, starting salaries for the graduates averaged $513. The average salary has increased 61 per cent in the last five years to $824 today.

For those who have earned additional degrees, the extra academic work has paid off even though their job experience has been reduced. Graduates with only bachelor's degrees average $815, those with master's $856, and Ph.D.'s $941. ◆

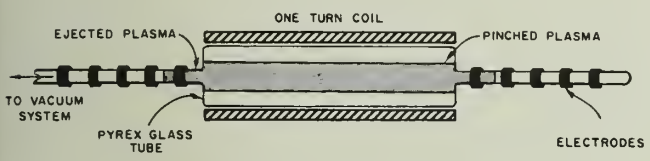
Mrs. Gaynelle Waad, a labaratary assistant in the Biaphysical Research Labaratary, is mapping nerve cells an a greatly enlarged phatamicrograph af brain tissue. Thausands af these slides were analyzed before the first brain nerve circuitry cauld be deciphered.

THEY'D RATHER SWITCH

Suppose you were running a big electronic gadget with a big, expensive tube — and you smelled smoke. Jump out the window? Nope. You'd pull the plug.

Sometimes it isn't that easy. Many of today's electronic devices operate at such high voltages and large currents that "pulling the plug" is a complicated and tricky operation. The protection of their components from arcing and overloads requires that currents, often very large, be shunted away as quickly and efficiently as possible.

An outgrowth of University of Illinois research may help solve the problem. Workers in the Department of Electrical Engineering Gaseous Electronics Laboratory, studying the behavior of highly ionized, high-electron-density gases subjected to large electric currents, have found a way to build a switch able to handle larger currents than any previous device. It doesn't look much like an ordinary plug.



The heart of the mechanism is a cylinder of low-pressure gas, surrounded by a large but simple electric coil. At either end of the cylinder are mounted the electrodes of the circuit to be shunted. When the switch is closed a large, short-duration electric current sent through the coil heats the gas (to about 70,000° F), ionizes it, and compresses it to a much thinner cylindrical form. This electromagnetic "pinch" causes the ionized gas to flow outward to the electrodes (at speeds up to twenty times the speed of sound), bridging them with a highly conductive path. The switch is fast, has low electrical resistance, and can carry millions of amperes of current.

This research, directed by Dr. Ladislas Goldstein, is concerned with discovering facts about ionized gases, not designing machinery — but the plasma switch is no less valuable for being incidental. ◆

ELECTRONICS AWARD TO PROFESSOR TYKOCINER

Professor Joseph T. Tykociner, pioneer in the field of "talkies," has been named to receive the Award of Merit from the National Electronics Conference at its awards luncheon, October 19, at McCormick Place in Chicago.

A professor emeritus of the University of Illinois, Professor Tykociner is one of three to receive the award since its inception by the NEC in 1944. Dr. Edward W. Ernst of the University of Illinois Electrical Engineering Department said Professor Tykociner is being given the award "in recognition of his many significant contributions during a career that spans half a century, to education and research in electrical and electronics engineering."

Professor Tykociner invented and first publicly demonstrated sound-on-film movies in 1922 at the University of Illinois. This demonstration heralded the advent of processes that started the motion picture toward its present state of development.

Now, at the age of eighty-seven, Professor Tykociner has returned from retirement to teach a new science he has founded — Zetetics, the science of research. He has published a book, *Research as a Science — Zetetics,* and teaches at the University of Illinois the only course in Zetetics offered anywhere in the world.

Born in Vloclawek, Poland, and educated in Cothen and Berlin, Germany, Professor Tykociner holds patents in submarine signaling, photoelectric cable testing, piezoelectricity, techniques of radio measurements, antenna models, and microwave development. ◆

A COLD ELECTRON, NOWADAYS, IS HARD TO FIND

There's a saying that hindsight is always 20/20. Many of the important discoveries of science, for example, look almost absurdly evident in retrospect — but they had to be discovered nonetheless.

Recently a University of Illinois researcher, Dr. Paul Goldan, made a discovery of this sort. The discovery was accidental, it made his work more difficult, it might have been anticipated; yet it was important in that it expanded our knowledge. As a staff member of the Department of Electrical Engineering Gaseous Electronics Laboratory, Dr. Goldan was studying the properties and behavior of gas plasma (electrically neutral gas with a high number of free ions and electrons) under the effect of electron-ion interaction. Ordinarily this effect occurs only at such high temperatures (within the sun and in thermonuclear reactions, for example) that experiments are difficult and expensive to conduct. But it was known that electron-ion effects also dominated plasma behavior at very low temperatures, which are relatively easy to handle, and so Dr. Goldan's work began there — at 440° F below zero.

Soon he struck a problem. While trying to determine the effective size of atoms in the plasma, closely related to the electron-ion collision rate, he discovered that electrons didn't seem to be colliding with single atoms at all. In fact, the collision rate indicated that the electrons were behaving more like clouds or waves than like particles.

This discovery was not unprecedented. The particle-wave "dual nature" of electrons has long been recognized; under the conditions of low temperature and resulting low speed it might have been predicted that the wave-like part of the electron's character would dominate its behavior. But the fact was that no one knew — not until now. ◆

PAVING THE WAY FOR NEW DESIGN STANDARDS

Keeping a car on the road can be a problem — but keeping a satisfactory riding surface on the road is a bigger one. Particularly in areas lacking good natural pavement materials, the problem of building stable, durable highways is acute. One possible solution is to use stabilizing agents to improve the characteristics of local aggregates.

The dramatic performance of stabilized materials in the recently completed AASHO Road Test has demonstrated that in many cases a poor quality aggregate can be upgraded to give performances superior to high-quality aggregates, and at lower cost. This and other evidence from in-service pavements has increased the interest in new stabilizing agents and better ways of evaluating them.

Now a research project to develop new methods for evaluating various soil stabilization agents is being conducted by the University of Illinois under the sponsorship of the Highway Research Board, National Academy of Sciences–National Research Council. The current three-year research program in the Department of Civil Engineering is directed by E. J. Barenberg.

The objective of the research program is to find techniques for testing stabilizing agents and for predicting their probable performance in pavements, thus making highway design easier and more certain. Most procedures available today for evaluating stabilized materials do not yield definitive data for use in design, nor can they effectively be used for comparison of the relative performance of pavement materials.

Under this program fundamental properties of a number of stabilized materials are being studied in the laboratory. From the properties determined by laboratory tests, the behavior of pavements under loads are then studied by testing model pavements in the U of I pavement test track (*Outlook,* May 1961). When the significant properties of the materials have been determined, procedures for evaluating the stabilized aggregates will be recommended.

Soils for testing in this program have been collected from Illinois, Virginia, North Carolina, Oklahoma, Kansas, and other states, giving the program a truly national scope. Many of the soils used are taken from existing pavements in the various states. The use of soils from in-service pavements is of particular importance as it permits a comparison of laboratory results with actual performance. Lack of correlation between laboratory and field results is a major reason for the absence of an accepted pavement design standard. One of the aims of the program is to eliminate this problem. ◆

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AT THE UNIVERSITY OF ILLINOIS

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THE ROCKETS' RED GLARE AND THE DAWN'S EARLY LIGHT

The sun's ultraviolet rays — not the dawn's earliest light — release the "piggyback electrons" which cause early morning increases in radio-reflective ionization of the earth's upper atmosphere, University of Illinois researchers have discovered.

Professor Sidney A. Bowhill of the Electrical Engineering Department's Aeronomy Group and George G. Kleiman, graduate student in physics, announced the finding after analyzing data from a July 15 experiment in which a series of three rockets was shot into the ionosphere to study atmospheric changes from dark to daylight. The project was sponsored by the National Aeronautics and Space Administration, and instrumented, in part, by the Coordinated Science Laboratory of the University.

Records from the rockets verified the existence of a suspected "C-layer" of ionization forty miles above the earth. This layer, weak at other times, was obvious in the early morning project, enabling Bowhill and Kleiman to trace the release of electrons which had attached themselves to gas molecules overnight. The University of Illinois tests showed that these "piggyback electrons" are not set free by the first touch of dawn, as had been believed. The earliest light to touch the ionosphere above any point on earth comes past the edge of the globe and through the atmosphere whose ozone layer, fifteen to twenty miles up, screens out most ultraviolet rays.

The "piggyback electrons" are not freed until a half hour after dawn, when the sun's ultraviolet rays strike them directly without interference from the atmosphere's ozone screen.

The University of Illinois experiment involved three Nike-Apache rockets shot by NASA from Wallops Island, Virginia, in the first series ever sent to explore ionospheric changes from dark to daylight. The first rocket was launched when darkness was complete over earth and sky; the second when sunlight streaking past the edge of the earth was striking the underside of the ionosphere, but the earth beneath was dark; and the third when full daylight existed.

The rockets were in the ionosphere from five to seven minutes, reaching altitudes of 96, 99, and 106 miles, and sending back records of conditions encountered. These records are still under study at the University of Illinois, as part of a general study of the highest part of the earth's atmosphere. ◆

HEATING SYSTEM REPORT AVAILABLE

Engineering Experiment Station Technical Report Number 9, *Performance of Three Ducted Electric Heating Systems in a Split Level Residence,* by James H. Healy and Murray N. Patterson, summarizes the performance of three types of residential electric heating units installed in an occupied, modern, split-level home. The units investigated included a central electric furnace, an air source heat pump, and individual branch duct heaters, all incorporating a ducted warm air distribution system.

Operating characteristics showing the variation of heat output to energy input as a function of outdoor temperature are reported, and comparisons of power consumption are made between the heat pump and resistance systems. In addition, the effect of outdoor temperature and humidity on the frequency of the heat pump defrost cycles are reported. The report is available for one dollar from the Engineering Publications Office, 112 Civil Engineering Hall, Urbana, Illinois 61803. ◆

This beautiful piece af furniture is really a thermal analag camputer develaped by Dr. L. D. Savage, Prafessar af the U of I Department af Mechanical and Industrial Engineering. The camputer is used far research an the behaviar af materials under variaus temperatures. Each af the baxes in the upright panel "cantains" a characteristic af a metal, and by cambining electronically twa ar mare baxes an innumerable cambinatian af desired campasitians af metals can be simulated. Their temperature behavior at a given time is then simulated and recorded. Evaluatians af these recardings will help predict faults that cauld accur at certain temperatures in materials used far the manufacturing af parts such as gas valves, cambustian chambers, ar fuel elements in nuclear reactors.

HORSE-AND-BUGGY SPEED LIMITS

The old gray mare's replacement is a sleek machine packed with horsepower. Modern turnpikes, expressways, and freeways are designed to carry these fast-moving vehicles if traffic densities are right, if driver conditions are proper, if vehicles are mechanically safe, if there are no foreign objects on the road, and many other "ifs." When the warning "SPEED KILLS" first appeared on posters, the intent was to slow the traffic down. Now it has been determined that speed too fast *for conditions* is a major cause of accidents and not just high speeds in general as has been frequently implied.

Dr. John E. Baerwald, Professor of Traffic Engineering and Director of the Highway Traffic Safety Center at the University of Illinois, has studied speed regulations for years. He recently noted that while we are building 300-horsepower roads, we still tolerate horse-and-buggy speed regulations. Normally, he indicated, legislative bodies and officials, state or local, are not competent to establish specific speed limits and therefore the following principles should apply:

a. Only qualified traffic engineers should be allowed to establish or revise speed limits after a thorough study of a given situation and condition.

b. Broad area speed limits for different types of conditions should be established by the state legislature. The authority to revise the speed limits should be delegated to competent and appropriate jurisdictions if and when warranted.

c. Local authorities and state highway commissions should be given the power by legislation to establish (upon the basis of a traffic engineering investigation) not only maximum but also minimum speed limits.

If motorists can be encouraged to drive at or near the same speed and to minimize maneuvering and passing, the highways will become safer. Reasonable, scientifically established speed limits will satisfy most drivers rather than frustrate them, as some of the horse-and-buggy limits tend to do.

Research to develop scientific criteria for the establishment of speed limits is conducted by the Department of Civil Engineering under the supervision of Professor Baerwald. The Illinois Division of Highways and the U.S. Bureau of Public Roads have co-sponsored this continuing study since 1955. ◆

STUDYING BY SATELLITE

Signals from the Beacon-Explorer B satellite are being used by University of Illinois researchers to study electron density and its fluctuating irregularities in the ionosphere. The satellite's first passage over the U of I campus was recorded at 8:05 a.m. October 10 at the Geophysical Observatory.

K. C. Yeh, Professor of Electrical Engineering, is in charge of the studies during the absence of Professor George W. Swenson, Jr., who is on leave at the National Radio Astronomy Observatory at Green Bank, West Virginia. Under Swenson's leadership the University has carried on intensive research on the irregular patches of electrons in the ionosphere which cause radio signals coming through it to scintillate in an effect similar to the twinkling of a star.

Scintillation and electron density of the ionosphere are both related to the sunspot cycle. The University's observations now cover more than half the eleven-year cycle, and will continue to gather information about the ionosphere.

Both electron density and irregularities in the ionosphere play important roles in long-range radio communications. Swenson and Yeh found in recording signals from other satellites that both change from day to night, season to season, and year to year. The effect was first noted here when signals were recorded from the first earth satellite, Sputnik I. It has also been noted

in signals from radio stars. Why electrons are sometimes found in patches and sometimes spread out smoothly is not known. Why they cluster mainly at night and mainly in the near-polar areas are also among questions to be answered.

Signals from several earth satellites, including two carrying transmitters built at the U of I (*Engineering Outlook,* February 1962), have been used to study the ionosphere. While their signals were useful, none of these was specifically designed, as is Beacon-Explorer B, for ionosphere study. The new satellite's radio frequencies and the height and direction of its orbit are specifically planned for study of the ionosphere by scientists around the world. Techniques for using it, based on University experience, have been presented in a widely distributed manual prepared by Swenson.

University research involves data being recorded at four stations. Most intensive records are those of the Geophysical Observatory just south of the campus. Another station is operated by University personnel at Michigan Technological University, Houghton, Michigan. Volunteer personnel operate University equipment at the Canadian government's Baker Lake Scientific Station, 190 miles south of the Arctic Circle. The Army Signal Corps operates University equipment at Adak, Aleutian Islands. ◆

CHEMICALS THAT WORK AGAINST ENGINEERS

Common table salt, sodium, and calcium chloride are well-known de-icing agents for highways. The disadvantage involved in their use is that they eat away concrete as well as the undersides of automobiles. Engineers have recognized for many years that the scaling of concrete is a direct result of de-icing agents spread on the roads.

From 1951 to 1961 the annual de-icing salt tonnage used for ice and snow removal more than doubled. As a result, the rate of deterioration of roads and concrete bridge floors was far more severe than previously noted. Maintenance costs, even on relatively new structures, have skyrocketed, and research concerning ways of making concrete immune to salt damage has been accelerated.

Laboratory tests have shown that concrete into which specified amounts of air are incorporated during mixing is highly resistant to salt deterioration. This discovery led to requirements by most agencies in charge of concreting that air be incorporated in the concrete to make it more durable. In many cases, structures built under these specifications exhibited the anticipated beneficial effects; however, in far too many instances deterioration was still evident.

Research is now being conducted in the departments of Civil Engineering and Theoretical and Applied Mechanics under the direction of Professor Clyde E. Kesler to investigate de-icer damage to concrete and to explain, perhaps, why some air-entrained structures resist damage much better than others. Since laboratory studies have shown that salt-resistant concrete can be built, the concrete properties must have been changed during or immediately after casting to have made it susceptible to deterioration. With this premise, investigators are reproducing possibly harmful field practices involved in concreting operations in order to evaluate their relative seriousness. Freeze-thaw tests, microscopic examination of air voids, and surface strength tests are all being used to assess durability of concrete specimens. When this phase of the work is complete and the most seriously harmful practices have been detected, recommendations can be made to eliminate the damaging practices and increase the resistance of concrete structures to de-icers. ◆

THE WATER EXPLOSION

Increasing prosperity and the population explosion are being accompanied by the "water explosion" — an increasing public demand for high-quality water. A continually increasing number of consumers expect an adequate supply of water at high pressure at all times of the day and night, and present-day distribution systems are being expanded to meet predicted demands. A group of researchers at the University of Illinois are studying the problems involved and are looking for answers to them.

Most water distribution systems are put under pressure by means of centrifugal pumps that operate most efficiently in a limited range near their design capacity. To meet wide fluctuations in demand it is normal to operate a complement of pumps of different design capacities in various combinations. To back up the pumps during peak usage periods a "silent pumping station," which is an elevated storage tank or a high-level ground storage reservoir, can be used. Such storage improves pumping efficiency by equalizing the output from pumping stations and by stabilizing system pressures. In the event of pumping station power failure, demand is served for a reasonable time exclusively from storage. The equalizing feature is also of great benefit when large flows for fighting fires are required. With equalizing storage, a whole day of demand can be met with a single pump, or at most with two pumps, making the system more susceptible to automatic or remote-control operation.

Today, the designer of a water distribution system is faced with many choices for expansion, but only a few

combinations of distribution piping, elevated storage, and pumps will meet service requirements with minimum capital outlay and optimum operating costs. The research group in the Department of Civil Engineering, which is under the direction of Professor M. B. McPherson, is studying criteria for the analysis of water distribution systems under a Public Health Service research grant. With the aid of a computer, the researchers will evaluate all combinations of pumps, storage capacity, demand schedules, pipe networks, and other variables required for full exploitation of equalizing storage. ◆

ELECTRONICS EXPERTS HOLD MEETING

More than three hundred of the nation's leading scientists and engineers in electronics met October 12 through 14 at the University of Illinois for a meeting of the United States National Committee of the International Scientific Radio Union.

Ninety-four papers on technical and scientific aspects of radio were presented in sixteen sessions held in the Illini Union. Members made visits to the University's electrical engineering laboratories and tours to its Wullenweber radio direction finder and to the giant radio telescope at the Vermilion River Observatory near Danville.

Professor Edward C. Jordan, head of the University's Department of Electrical Engineering and vice chairman of the national committee, was host for the meeting, which was cosponsored by the Institute of Electrical and Electronics Engineers.

Commissions in the meeting dealt with radio propagation in non-ionized media, ionospheric radio, magnetospheric radio, and radio waves and transmission of information. A special session was held on electroacoustic waves, an area of great current interest. ◆

PEOPLE AND PLACES

Professor James E. Stallmeyer was selected as one of the recipients for the Adams Memorial Membership Awards by the American Welding Society. This award is in honor of the AWS founder, Comfort A. Adams, for an educator "whose teaching activities were considered to advance welding in their respective institutions."

Dr. Ven Te Chow, Professor of Hydraulic Engineering at the University of Illinois, has been appointed by **Dr. Frederick Seitz,** President of the National Academy of Sciences and Vice-President for Research at the U of I, as a member of the U.S. National Committee for the International Hydrological Decade to advise and consult with the government through the Department of State on UNESCO activities in the IHD.

Clyde E. Kesler, Professor of Civil Engineering and of Theoretical and Applied Mechanics at the University of Illinois, has been nominated as Vice-President of the American Concrete Institute for a two-year term. He will be formally elected at the sixty-first annual convention in March, 1965.

Dr. Ven Te Chow, Professor of Hydraulic Engineering, U of I Department of Civil Engineering, is the editor of a new serial publication entitled *Advances in Hydroscience.* Academic Press Inc., New York and London, has just announced Volume 1. ◆

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 5, NO. 10, DECEMBER 1964

In the order listed, this issue contains articles on the following subjects:

THERE'LL BE A HOT TIME IN THE IONOSPHERE TONIGHT, AS USUAL

Why are some electrons twice as hot as their surroundings? This phenomenon of the ionosphere (the radio-reflective atmosphere layer that makes long-range communications possible) may be explained by a theory developed by researchers at the University of Illinois Department of Electrical Engineering. By introducing the concept of "non-local heating," this theory has succeeded in relating previously gathered data from rocket probes and radio measurements (*Outlook,* April 1963) and in explaining the mysterious presence of "hot electrons" in the upper layers of the ionosphere.

According to this theory, the sun's ultraviolet radiation releases electrons from atoms in the middle layers of the ionosphere with such energy that many of them spiral upward to the protonosphere (the highest ionospheric layer) along the lines of force of the earth's magnetic field. This energy is dissipated in collisions with other electrons, heating them to temperatures as high as 3,000°C. The temperature would rise even higher were it not for the fact that hot electrons are very efficient conductors of heat. Within minutes after sunrise the electron temperature throughout the ionosphere takes up the altitude dependence that is required to conduct this heat downward to the lower levels of the atmosphere.

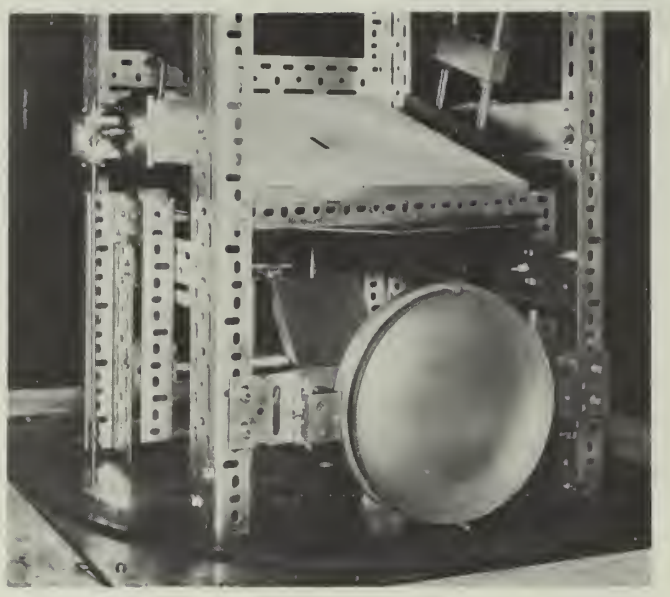
At sunset the source of heat is cut off, but the amount of energy stored as heat in the protonosphere is sufficiently large that it cannot be immediately carried downward by the conduction process. The protonosphere then acts as a vast heat reservoir, gradually releasing this energy to lower levels. Thus the theory suggests a mechanism for heating the nighttime ionosphere.

The non-local heating theory, developed by Research Assistant J. E. Geisler under the supervision of Professor Sidney A. Bowhill, was prompted when analysis of data from recent sounding rockets revealed that some high-altitude electrons had unexplainably high temperatures. The theory was tested by using its hypothesis to produce a computer-created table of electron temperatures which agreed closely with these data. Further sounding rocket measurements are being made by the University of Illinois Electrical Engineering Department. ◆

SUBMILLIMETER WAVE SPECTROMETER

Long ago man discovered that every substance has its own unique "fingerprint": a series of dark bands in the spectrum of electromagnetic radiation (including light) at specific wavelengths, in a pattern peculiar to that substance alone. For some portions of the spectrum (the visible light region, for example) the location and width of these bands has been precisely determined. For other wavelength ranges, however, notably that of waves from a fraction of a millimeter to a few millimeters long, our knowledge of the spectroscopic characteristics of matter has been hampered by a lack of ultramicrowave sources and spectrometers sensitive to this type of radiation.

Now a University of Illinois researcher, R. H. R. Roldan, has built a powerful new instrument to reveal the spectroscopic characteristics of matter in the submillimeter region of the spectrum. Using a 16-inch-wide radiation beam, this spectrometer has more than twice the resolving power of the largest previous comparable device. The spectrometer uses fine gratings to break the radiation into its component wavelengths, and operates in a high vacuum so that water vapor in the air cannot absorb power from the waves passing through it.



A close-up view of the optical part of the manochramatar used ta analyze the spectrol characteristics af materials in the ultromicrowove region.

One of the vacuum grating spectrometer's first uses will be different from its main task: it will measure the output from a gas laser, a device that holds considerable promise as an eventual radiation source for submillimeter spectroscopy.

Eventually the instrument will be used to provide needed information about many properties of molecules, crystal structures, and solid dielectric materials at the submillimeter radiation range. Besides yielding more detailed data than previous spectrometers, this more powerful device can record spectra in less than half the time previously required, insuring more uniform conditions during measurements, and greater accuracy.

A product of ultramicrowave research conducted in the University of Illinois Electrical Engineering Department under the supervision of Professor P. D. Coleman, the vacuum grating spectrometer will be a valuable tool in filling one of the "holes" in our knowledge of the properties of the materials around us. ◆

FOR THIS ACTION, AN APPARENTLY UNEQUAL REACTION

A device soon to be built at the University of Illinois will exert so much pressure on the ground that it will have to be restrained from being launched like a missile. When it is in use, an unbalanced force equivalent to the thrust of our largest missile booster, the Saturn, will act upward on its support system, which will be firmly anchored to a 350-cubic-yard block of concrete. It is designed to simulate underground nuclear blast pressures.

For a number of years U of I civil engineers have studied the dynamic response of structures subjected to nuclear blasts. The new device, called the dynamic load generator, will make it possible to determine the dynamic strengths of soils and the response of structures buried in them.

Various types of gas-operated dynamic loading machines have been developed in the Civil Engineering laboratories during the past ten years, but they have been relatively small. To study the problem of the interaction of a soil and a buried structure, much larger specimens must be tested so that structural models of reasonable size may be imbedded within the soil specimen. The dynamic load generator was consequently designed so that it will be capable of applying a gas pressure of at least 800 pounds per square inch to the top surface of a soil specimen 4 feet in diameter and 8 feet deep. The pressure may be maintained for a period of time or decreased at a controlled rate to simulate the overpressure from a nuclear detonation.

For this unique non-explosive device, seven individual high-pressure gas-operated valve assemblies will be mounted in a steel forging 2½ feet thick and 6 feet in diameter. To load a specimen, the individual assemblies will discharge helium gas into a common chamber above the surface of the soil specimen, producing a uniform pressure of 800 psi in 3 milliseconds. The upward force on the generator is so high because a stress wave will travel faster through the support structure than the soil.

Research Assistants J. D. Prendergast and J. J. Healy are inspecting one of the seven valve assemblies for the dynamic load generator, which is being installed in the Civil Engineering Department's Structural Dynamics Laboratory.

The development of the dynamic load generator has been under the direction of Professor G. K. Sinnamon and has been sponsored by the Air Force Special Weapons Center and the Defense Atomic Support Agency. It will be housed in the new structural dynamics laboratory which is being built south of the campus. Its massive restraining foundation will be separate from the other foundations of the laboratory to minimize disturbances in the rest of the building. ◆

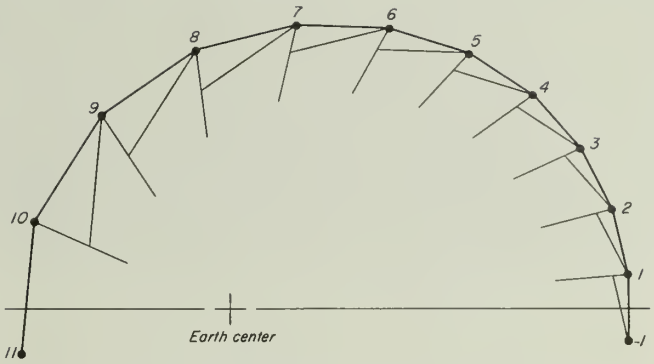
SATELLITE ORBITS FOR BEGINNERS

How do you know where a satellite is going? Most scientists and engineers at the University of Illinois could answer this question, but whether or not you could understand the answer would depend upon your math background. The path of a body in a force field such as the earth's gravitational field is described by a differential equation, which requires calculus to understand. High school students and college freshmen are the ones who most often ask questions like the one above, and they are usually disappointed because they are unable to understand the explanations.

In the case of the timely question of how to predict the orbit of a satellite, Professor L. S. Lavatelli of the U of I Physics Department has combined two well-known mathematical techniques (integration by central differences and graphical expression of vector equations) to make it possible for high school and freshman college students to plot the path of a body in any force field. Only a good high school background in physics is required to perform the exercise.

According to Professor Lavatelli, so much of the teaching of physics is influenced by the mathematical background of the student, or the lack of it, that beautiful, simple, and elegant phenomena are frequently skipped over, and teachers dodge behind the phrase "beyond the scope of the course." Many students, for whom the introductory physics course is their last, perhaps never realize that they know enough physics to comprehend satellite motion and go away feeling that there is some other mysterious physical principle at work, known only by a select few. The necessary understanding has been in the public domain since Newton put forth his principles three hundred years ago; that beginning students can now put it to use is a forward step in education.

The exercise consists of the iterative vector addition of position and displacements due to velocity and acceleration vectors by using nothing more than a ruler, parallel rules, a pencil, and a 22-inch by 35-inch sheet of paper. The student starts with a velocity vector representing the speed and direction of the satellite at the initial position. He then adds an acceleration vector that tells him which



The plat af a satellite arbit in the exercise that Prafessar Lavatelli develaped is a cambinatian af displacements derived fram velacity and acceleratian vectars. The arbit shawn is abaut the same shape as that af Telstar II.

way it will turn, and the sum gives him a new velocity and the next position. To this velocity and position he again adds the acceleration, which takes him to the next step and so on jumping across the sheet. The system would be perfectly accurate if the steps were infinitely small. Since the particle doesn't move in steps, however, but in a smooth curve, the steps introduce error. But the smaller the steps the longer it takes to graph the orbit, so a compromise has to be made between accuracy and the length of the experiment. As it is set up the exercise takes less than two hours to develop an orbit with only a 6 per cent error.

For the first time students can see the interaction of acceleration and velocity determine the path of a body. As Professor Lavatelli says, it takes very little imagination to project the lines being drawn on the paper to the real motion of a planet or satellite, and the student can easily become involved with the visual drama of the interplay of force, velocity, and position.

This interesting and simplified approach to a very complicated problem shows that science can be made more interesting for the beginner. And for this kind of problem anyone with less math than calculus is a beginner. ◆

REPORT ON TESTS OF HIGH-STRENGTH BOLTS AVAILABLE

Bulletin No. 469, *Studies of the Behavior of High-Strength Bolts and Bolted Joints,* by E. Chesson, Jr., and W. H. Munse of the Civil Engineering Department, reports on the testing of high-strength bolts to determine the effect of washers, method of tightening, and five-per cent slopes of the surfaces at the head and nut of the bolt. All specimens were four-bolt, double-lap shear-type joints and included connections designed with the inside or with the outside plates critical. This publication is available for $1.50 per copy from Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois 61803. ◆

TECHNICAL REPORT NUMBER 10 PUBLISHED

An annotated bibliography of papers on the problem of bending of elastic plates has been published by the University of Illinois Engineering Experiment Station as Technical Report Number 10.

Elastic Plates: Annotated Bibliography 1930-1962, by three members of the Department of Theoretical and Applied Mechanics, George E. Sliter, Robert J. Nikolai, and Arthur P. Boresi, lists 994 English language papers published between 1930 and 1962, and briefly describes more than 850 of them. The papers cover the general problem of bending of elastic plates, but do not include these areas: plane problems of elasticity; plastic, elasto-plastic, and visco-elastic behavior of plates; aerodynamic problems of panel flutter; buckling of plate webs; corrugated plates; and experimental methods.

The Technical Report, which should be a valuable reference work for engineers, is available for one dollar from the Engineering Publications Office, 112 Civil Engineering Hall, University of Illinois, Urbana 61803. ◆

NEW PUBLICATION ON ROLLING ELEMENT FAILURES

Bulletin No. 468, *Surface Failure of Bearings and Other Rolling Elements* by G. J. Moyar and J. Morrow, is now available from Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana 61803, for two dollars per copy. The bulletin describes two modes of surface failure in bearings and other rolling elements: fatigue pitting and cumulative plastic deformation. Special attention is given to the development of methods of data correlation and the influence of size and configuration effects in standard laboratory, bench rig, and full scale bearing tests. A classification of research in the field and a literature review pertinent to bearing failures and excessive rolling resistance is included. ◆

PEOPLE AND PLACES

Professor A. P. Boresi of the Department of Theoretical and Applied Mechanics of the University of Illinois has recently been appointed to the board of section editors of a new international journal, *Nuclear Structural Engineering,* devoted to the civil, mechanical, and chemical structural engineering problems of nuclear energy.

Professor C. E. Taylor of the Department of Theoretical and Applied Mechanics of the University of Illinois has recently been elected vice-president of the Society for Experimental Stress Analysis for a two-year term.

Professor Thomas J. Hanratty, University of Illinois Department of Chemical Engineering, received the William H. Walker Award of the American Institute of Chemical Engineers at the Institute's annual meeting December 8 in Boston. The award is for "an outstanding contribution to the literature of chemical engineering."

Four students in Mechanical and Industrial Engineering received awards in the annual Lincoln Arc Welding Foundation's nationwide contest. The third-place award was presented to T. C. Skierski; fourth place, R. T. Marek; fifth place, A. Ness; and sixth place, M. K. Mundy. ◆

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 6, NO. 1, JANUARY, 1965

In the order listed, this issue contains articles on the following subjects:

A MUD HUT OR A HOUSE IN THE SUBURBS?

Today engineers have an opportunity they have never had before. They can take a job that pays $75 a month, offers unusual living conditions, and has no future at all. Another attractive feature of this job, in many cases, is that they can work with second-rate equipment or perhaps no equipment whatever. How? By volunteering for the Peace Corps. But the real question is: Why do college graduates take such positions?

Peter Donalek, a U of I engineering graduate of 1961, stationed in Rio de Janeiro, says, "In my year in the Peace Corps I have been at the front line of local events more times than I ever was in the rest of my life. What I mean is this: I have been in the situation where I was the one who said 'throw the switch; it's okay.' You can't understand what it's like, but at home I would not have been in this position of responsibility for at least another ten years."

Mr. Donalek is working in the main office of a commission in Rio de Janeiro similar to the United States' T.V.A. From this office the entire electrical development of the São Francisco river valley is directed; the river is the sixteenth largest in the world.

Many volunteers emphasize that the only limit for an engineer in the Peace Corps is himself. In many cases he is the best educated person on a project. The problems that arise must be solved by him or not at all. Thus he has the opportunity to take the initiative and develop the technical competence of his associates and to get results that are limited only by his ability to organize and to get cooperation from fellow workmen. As one volunteer put it, "We don't need money. We need people — people who will be willing to face the difficulties of rural life, to live and eat like their co-workers, to earn their approval and respect . . . to wait patiently for that precise moment to introduce a new concept."

Some of the rewards come from working with people of a different society with different values. Raymond Willem, a 1959 graduate of the College of Engineering, stationed in Nigeria, comments, "Since coming I have learned that efficiency is something that all societies do not place the same value on. Our society places a high value on efficiency, and to live in a society that does not has caused me some frustrations."

Mr. Willem is teaching science and math to students at about the level of college freshmen in the United States. He points out that many engineers in the Peace Corps have teaching assignments.

Volunteers almost unanimously agree that the man who puts two years of his life into the Peace Corps will experience a real sense of accomplishment from helping people develop their country. He will also be rewarded, not monetarily or with a position of prestige in a big company, but by unequaled experience in another segment of the world that he couldn't get in a dozen years on any other job. ◆

Pressure checks are being performed on the modules of the U of I rain maker to be used in the investigation of watershed hydraulics. This information is obtained for a range of intensities up to 27 inches of rainfall per hour.

WHEN IT RAINS, IT POURS OUT INFORMATION

Transforming a brainstorm into a rainstorm is not an easy task, but such a transformation is taking place at the University of Illinois. It is being done in the Civil Engineering Department's Hydraulic Engineering Laboratory by a group of researchers under Dr. V. T. Chow, Professor of Hydraulic Engineering. The device they are building will be a 1600-square-foot model watershed over which they will be able to create rainstorms of varying intensity, duration, raindrop size and terminal velocity, and controllable direction of movement.

Creating storms in the laboratory has more advantages for observers than just keeping them in out of the weather: rainfall of any type can be created, and storms can be moved up, down, or across the watershed; physiographic features of the model, such as basin area, slope, soil type, infiltration, and overland flow can be varied to suit the study in progress; and experiments can be conducted without regard to (real) weather, time of day, or season.

Many plans have been analyzed during the past year to obtain a satisfactory procedure for controlling the many variables which may influence the runoff from watersheds. As a result of these studies, the small model shown in the picture above was built, and the equipment decided upon was tested before work on the 40- x 40-foot model was started.

The control of the model watershed will be by a solid-state electronic computer. The 230,400 polyethylene capillary tubes, which will allow formation of raindrops approximately 3.2 millimeters in diameter, will be controlled by 100 variable-flow valve units. All valves can be altered individually in a period of ten seconds, allowing the desired storm patterns to be produced.

The surface of the model will be constructed in such a way that it can be modified in roughness, shape, slope, permeability, and other essential considerations. The rainfall that hits it will proceed to the outlet and will subsequently be measured to give a time distribution of runoff, commonly called a hydrograph. The process control assembly will record and store the outflow measurement, and print out the inflow and outflow data at the completion of the experiment.

When it is finished, this model watershed and its rain-making apparatus should make it possible to solve many problems that have previously been difficult or impossible for the hydrologist to study. Their importance to engineers is obvious when they are considered in relation to the design, construction, and maintenance of culverts, bridges, highways, and other familiar features of today's landscape. ◆

AERONOMY RESEARCH WHERE THE BUOYS ARE

Three rockets carrying instruments for University of Illinois upper atmosphere research made flights over the Atlantic in November, and five more will be launched this year in the Pacific. The control center for these experiments is a unique floating laboratory — the USS Croatan, a Navy aircraft carrier equipped to transport, launch, track, and retrieve information from sounding rockets.

U of I projects are among those to be carried by 40 two-stage Nike-Apache and Nike-Cajun rockets to altitudes of 100 miles or more. The vessel also will launch 34 smaller weather rockets to heights of 40 or 50 miles. The research program is sponsored by the National Aeronautics and Space Administration, and directed by Electrical Engineering Professor Sidney A. Bowhill.

In the first test on November 10, land and sea bases worked together on a dawn study with a rocket shot at 6:07 a.m. EST from Wallops Island, Virginia, at a low angle, passing over the Croatan at sea while going eastward from darkness into daylight. Its radio reports were recorded both on land and shipboard. Antennas installed on the Croatan were tested for the University's project by flying a duplicate of the rocket's instruments over the

vessel by helicopter. The University's first rocket also carried experiments for the University of Michigan; University of Birmingham, England; and the Geophysics Corporation of America.

The second and third rockets were fired on November 19 at 3:20 and 5:02 p.m. EST to investigate the daytime ionosphere and ionospheric changes from daylight to darkness. In a companion project last July, rockets were shot from the NASA base at Wallops Island to study dawn changes from darkness to daylight (see *Outlook,* November 1964). The second rocket flew from Wallops Island, and was tracked by both land-based and shipboard instruments. The Croatan launched and tracked the third vehicle, which was instrumented to find out whether ionospheric changes at dusk parallel those at dawn.

This year's research will be conducted in the region of the magnetic equator during a three-month cruise to eastern reaches of the South Pacific. Rockets launched from the Croatan for the U of I will investigate effects of the earth's magnetic field upon the lower ionosphere. The rockets will carry equipment for several experiments, including radio propagation studies by Professor Howard W. Knoebel of the University's Coordinated Science Laboratory.

Technical personnel from the Aeronomy Laboratory and the Coordinated Science Laboratory are now aboard the Croatan, which departed early this month for the 1965 series of experiments. ◆

WATER FOLLOWS POPULATION EXPLOSION

Increasing demands on water storage and distribution by mushrooming suburbs and rural additions was the basis for problems discussed by participants in the Sixth Sanitary Engineering Conference held last January at the University of Illinois. Thirteen experts from all over the country presented papers on *Pumping and Storage Facilities in Water Supply Systems.* The proceedings of the Conference has just been published under this title as Engineering Experiment Station Circular 83 and is available for $2.00 per copy from the Engineering Publications Office, 112 Civil Engineering Hall, University of Illinois, Urbana 61803.

The series of Sanitary Engineering conferences, held every year since 1959, is the product of a close cooperation between the Illinois State Department of Public Health and the University of Illinois, who are the joint sponsors of each Conference. Proceedings of the last four Sanitary Engineering conferences — Circular 69, *Radiological Aspects of Water Supplies;* Circular 71, *Disinfection and Chemical Oxidation in Water and Waste Treatment;* Circular 75, *Water Distribution Systems;* and Circular 81, *Quality Aspects of Water Distribution* — are also available at two dollars per copy. ◆

CORROSION STUDY RESULTS PUBLISHED

The Effects of 60-Cycle Alternating Currents on the Corrosion of Metals Buried in Soils, by Walter H. Bruckner, describes experiments with laboratory operated cells which simulated field conditions of buried metals. The effects of a–c on corrosion were studied with and without a d–c component in the a–c circuit. Alternating current was found effective in accelerating the soil corrosion of all metals tested, including ferrous and nonferrous alloys.

One of the first systematic studies of a–c corrosion effects in the field, the bulletin provides useful information for corrosion, petroleum, electrical, and mechanical engineers. The report is available as Engineering Experiment Station Bulletin No. 470 and may be obtained for $1.50 from the Engineering Publications Office, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois 61803. ◆

A new award, *College of Engineering Alumni Honor Award for Distinguished Service in Engineering,* will be given to as many as five University of Illinois Engineering alumni in May. The medal, designed by Frank Galla, former staff member of the U of I Department of Art, will be given to alumni or former staff members who have distinguished themselves by outstanding achievement in leadership in planning and direction of engineering work, fostering professional development of young engineers, or in contributions to knowledge in the field of engineering. Nominations for the first awards are due to the Dean of the College of Engineering by February 20.

PEOPLE AND PLACES

Dr. Ven Te Chow, U of I Professor of Hydraulic Engineering, is the editor-in-chief of a 1467-page publication entitled *Handbook of Applied Hydrology — A Compendium of Water-Resources Technology* published by McGraw-Hill Book Company.

Herbert A. Laitinen, Associate Head of the Department of Chemistry and Chemical Engineering at the University of Illinois, was awarded the Outstanding Achievement Award by the University of Minnesota, the highest award that school can give an alumnus. Laitinen was cited as a "painstaking researcher, dedicated educator, popular lecturer, originator of modern analytical laboratory techniques, acknowledged leader in the fundamentals of electrochemical methods, and respected member of national and international committees."

C. M. Wayman, Associate Professor of Metallurgy at the University of Illinois, is the author of *Introduction to the Crystallography of Martensitic Transformations,* published by Macmillan as a part of their new Materials Science Series.

Professor **William L. Everitt,** Dean of the U of I College of Engineering, and Professor **Nathan M. Newmark,** Head of the U of I Department of Civil Engineering, have been named founding members of the National Academy of Engineering. Formation of the new academy was announced December 11, 1964. It will share in responsibility given the National Academy of Sciences to advise the federal government in all areas of science and engineering.

Professor **J. E. Stallmeyer,** Department of Civil Engineering, was one of five recipients of the Adams Memorial Membership Award made by the American Welding Society at its annual meeting October 5 in San Francisco.

Professor **Sidney A. Bowhill** of the U of I Department of Electrical Engineering attended an international seminar on sounding rocket experiments and techniques early this month in India. The meeting, which was sponsored by the Indian government's committee on space research, heard Professor Bowhill deliver a paper on "Problems of the Lower Equatorial Ionosphere 60-100 km Region."

David L. Junchen, a one-time quiz kid who at ten won more than $43,000 in prizes, has been selected as last year's outstanding freshman in the University of Illinois College of Engineering. A student in electrical engineering, he has a 4.85 scholastic record. ◆

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 6, NO. 2, FEBRUARY, 1965

In the order listed, this issue contains articles on the following subjects:

A SUMMARY OF LAST YEAR'S RESEARCH

The 1964 edition of *A Summary of Engineering Research,* containing descriptions of the hundreds of research projects that were being conducted in the College of Engineering during the last fiscal year, is now ready for distribution. Amply illustrated with photographs, the 176-page *Summary* is divided into sections devoted to the various departments of the College. Within these sections, listings of individual research programs indicate the project title, investigators, publications and theses resulting from the program, sponsors, and a brief description of the work. A new feature of this edition is a subject index in the back of the book. The *Summary of Engineering Research* is available without charge from the Engineering Publications Office. ◆

A WEIGHTY PROBLEM FOR UTILITY COMPANIES

A model of a power transmission line in the basement of Talbot Laboratory may give the answer to a current electric utility problem: how much weight can utility poles stand without buckling? Present wooden structures have strength enough to support the transmission lines now in use, and there is even a possibility that additional conductors can be safely added — but as yet no one knows for sure.

Professor George Costello of the University of Illinois Department of Theoretical and Applied Mechanics is exploring this problem in a study supported by the Illinois Power Company. Dr. Costello's study is a theoretical analysis backed up by experimental tests on the model system. These tests are performed on 150 feet of line strung on 12-inch high wooden H-frame structures. External loads are placed on the system and the resulting deflections are measured. Ice accumulation, for example, is simulated by the addition of carefully weighed weights to the lines. Many additional tests are also being made in an effort to obtain data on all the factors pertaining to excess loads on such structures.

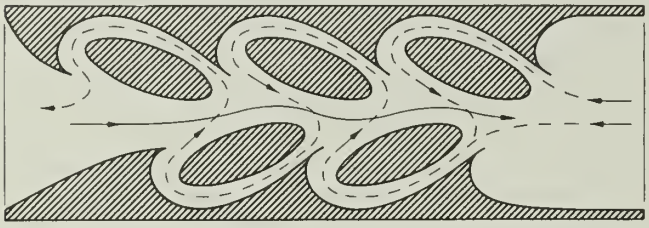
One of the interesting results obtained from the study is the conclusion that as the load on the poles is increased, the structures may become stronger. This is because the power lines tend to restrain the structure from deflecting. However, as the number of poles increases, this restraining effect decreases. These analyses and experiments have already provided much-needed information to electric utility companies, and the results may lead to the first published information on the subject. ◆

THUMPTHUMPTHUMPTHUMPTHUMP

An engine with a pulse may someday power airplanes, cars, or power generators. The man learning whether and how is Professor R. W. McCloy of the University of Illinois Department of Aeronautical and Astronautical Engineering. Professor McCloy is studying the problems of pulsating combustion, a principle of engine operation most successfully used in the notorious German V-1 "buzz bomb" missile.

Essentially, a pulsating combustion engine generates power by burning fuel in explosive bursts in an empty chamber, instead of in a piston cylinder, or steadily, as most gas turbine engines do. This intermittent firing is the source of the pulsating combustion engine's most noticeable defect: noise. Unmuffled, the "pulse" of the engine might be mistaken for a steam calliope with all the stops out. Previously, too, pulsating combustion engines have been limited to lives of only a few hours by the high stresses imposed on the intake valves, the engines' only moving parts.

An obscure idea by a genius of the past may overcome this defect. In 1920 Nikola Tesla, the prolific inventor responsible for much of the theory of alternating current, patented a "valvular conduit," a valve which operates without moving parts (see picture below). Professor McCloy is gathering data about the performance of the valvular conduit with the hope of using it to replace the troublesome mechanical valves of pulsating combustion chambers. In addition, he is directing a systematic study of the effect of combustion chamber dimensions on performance. Together these investigations may point the way to an engine with no moving parts.



Like a madern superhighway, the Tesla valvular canduit lets fluids travel smaathly — in ane directian. Fluids such as air entering fram the left (salid arraw) chaase a simple, straight-thraugh path af law resistance. Air fram the right, hawever, far aeradynamic reasans takes the circuitaus raute af the dashed arraws, a langer, slawer path. Thus the canduit acts like a leaky valve, but withaut any maving parts.

For aircraft propulsion, such an engine could be operated alone as a jet, and for automotive or other applications a turbine would be coupled to extract power to drive the vehicle. In automotive use the pulsating combustion gas turbine would not require the regenerator and could reduce the number of compressor stages that make present gas turbines so expensive.

Ultimately Professor McCloy's research may lead to engines for cars, for example, so inexpensive, so tolerant of fuel variations, and so durable that even advertising writers may turn honest. But obsolescence planners are shivering. . . . ◆

PROCEEDINGS ON CIRCUIT AND SYSTEM THEORY AVAILABLE

The second annual Allerton Conference on Circuit and System Theory was held at the U of I on September 28, 29, and 30, 1964, under the direction of Professors M. E. Van Valkenburg and W. R. Perkins of the Department of Electrical Engineering and the Coordinated Science Laboratory. The conference was devoted primarily to the theoretical aspects of the related areas of circuits, networks, and systems. Participants from government, industry, and universities came from as far away as Italy.

The *Proceedings of the Second Annual Allerton Conference on Circuit and System Theory* is now available. This volume is over 900 pages long and contains more than 150 illustrations. Conference topics include Control and Communications Systems, Filter Theory, Nonlinear Theory, System Theory, Topological Methods, Graph Theory, Optimum and Learning Systems, Circuit Theory, Active Network Theory, and Codes and Sequential Machines. Copies of the *Proceedings of the First Allerton Conference on Circuit and System Theory*, held in 1963, are also available. Copies of either Proceedings may be obtained for $10.00 each from the Engineering Publications Office. ◆

PORTRAITS OF THE EARTH

Just as you can recognize a friend in a photograph, you can identify a portion of the earth's surface from a picture by its special characteristics. It is a special arrangement of physiognomic features that enables you to identify your friend, and a certain arrangement of physiographic features that permits the identification of a particular soil or rock deposit. Of course the quality and scale of the picture affect the ease of identification in either case. Because the man's face is relatively small, the camera must be close so detail will not be lost. Because the earth is so large, the camera must be far away to pick up enough detail. Consequently, the most-used portraits of the earth are airphotos taken from aircraft or satellites with special cameras. They are useful for location studies of highways and airports, for rural and urban planning, and for detailed soil surveys for all types of construction engineering projects.

Research on the use of airphoto interpretation techniques in the Department of Civil Engineering has been carried on at the University of Illinois for many years, supported mainly as a part of the Illinois Cooperative Highway Research Program. This research, under the direction of Professor T. H. Thornburn, has led to the development of methods for the production of soil engineering maps from the study of airphotos in conjunction with available soil and geologic information. Within the last year more than twenty-five stereograms showing typical photo patterns of Illinois soil areas have been added to the file of the University Committee on Aerial Photography.

The prediction of the engineering characteristics of a given area is possible once the nature of the deposits in the area is identified from the airphotos. This is possible because various types of soil and rock deposits show distinctive photo patterns which can be identified on the basis of such elements as land form, regional drainage, erosional features, color tones, and vegetation.

In the past, airphoto interpretation has been primarily a qualitative technique, but research recently inaugurated by the Civil Engineering Department is aimed toward making it quantitative. Professors H. M. Karara and T. K. Liu have joined with Professor Thornburn and

Captain R. R. Vadnais, USAF, graduate student in Civil Engineering, in developing this new area of research. With modern photogrammetric and computing equipment it is possible to express land form and drainage characteristics in numerical values by measurements taken from airphotos. If it can be shown that a particular combination of such measurements is characteristic of a particular set of terrain conditions, then the process of airphoto interpretation can be mechanized or perhaps even automated. In this way, large and relatively inaccessible areas can be examined and their engineering characteristics predicted. Eventually the surfaces of distant planets may be analyzed in this manner and prospective landing sites for space vehicles quickly evaluated. ◆

DIGITAL COMPUTER PROGRAMS PUBLISHED

Linear Network Analysis and Realization Digital Computer Programs: An Instruction Manual, by D. A. Calahan, describes digital computer Fortran programs for the analysis and realization of linear electrical networks and gives ten examples of their use.

The analysis program requires a list of elements, the input and output node numbers, and the type of desired network function. The program then calculates the coefficients of the network function, the poles and zeros, frequency response, and transient response to an arbitrary input.

For input data, the realization program requires an existing design which is in some sense close to its final form. The element values are then perturbed until the final design (if possible) is achieved. The principal features of the realization program are its abilities to accept arbitrary topologies, to "grow" new elements, and to converge rapidly.

This instruction manual, Bulletin No. 472, is priced at $10.00. A Fortran Source Language deck of each program is available from the author for a nominal charge. ◆

PUBLICATION ON BACKSCATTERING FOR GAMMA RAYS

Backscattering for Gamma Rays from a Point Source Near a Concrete Plane Surface, Bulletin No. 471, is available from the Engineering Publications Office. The author, Arthur B. Chilton, is an Associate Professor of Civil Engineering and of Nuclear Engineering at the University of Illinois. The Bulletin costs $1.50.

Backscattering factors, as fractions of a direct dose rate in a vacuum, are obtained for point sources of gamma radiation (specifically Cesium-137 and Cobalt-60) placed near a plane interface between vacuum and concrete. The results are considered practically applicable to some air-concrete or air-ground interface situations.

The basic methodology relates to infinite planes; however, factors for correcting these values for certain finite plane cases are derived. The techniques for making the calculations for the specific radioisotopes indicated are generally applicable to any monoenergetic or mixed energy source having photons within the energy range from 0.2 MeV to several MeV. ◆

ORDER FORM

- ☐ Tech. Report 7, *Urban Highway Planning,* J. M. Heikoff. *One dollar.*
- ☐ Tech. Report 8, *Comparative Performances of Year Around Air Conditioning in a Split-Level Residence,* E. J. Brown, J. H. Healy, and B. W. Hryekewicz. *One dollar.*
- ☐ Tech. Report 9, *Performance of Three Ducted Electric Heating Systems in a Split-Level Residence,* J. H. Healy and M. N. Patterson. *One dollar.*
- ☐ Tech. Report 10, *Elastic Plates: Annotated Bibliography 1930-1962,* G. E. Sliter, R. J. Nikolai, and A. P. Boresi. *One dollar.*
- ☐ Circ. 82, *Engineering Departmental Reports and Theses, 1963. No charge.*
- ☐ Circ. 83, *Pumping and Storage Facilities in Water Supply Systems,* the proceedings of the Sixth Sanitary Engineering Conference. *Two dollars.*
- ☐ Circ. 84, *A Tabulation of Some Semiconductor Integrals,* R. M. Brown and N. K. Hindley. *One dollar.*
- ☐ Bull. 467, *An Investigation of a Reinforced Concrete Rigid Frame for Farm and Light Industrial Structures,* E. D. Rodda and M. L. Paul. *Two dollars.*
- ☐ Bull. 468, *Surface Failure of Bearings and Other Rolling Elements,* G. J. Moyar and JoDean Morrow. *Two dollars.*
- ☐ Bull. 469, *Studies of the Behavior of High-Strength Bolts and Bolted Joints,* E. Chesson, Jr., and W. H. Munse. *One dollar and fifty cents.*
- ☐ Bull. 470, *The Effects of 60-Cycle Currents on the Corrosion of Metals Buried in Soils,* W. H. Bruckner. *One dollar and fifty cents.*
- ☐ Bull. 471, *Backscattering for Gamma Rays from a Point Source Near a Concrete Plane Surface,* A. B. Chilton. *One dollar and fifty cents.*
- ☐ Bull. 472, *Linear Network Analysis and Realization Digital Computer Programs: An Instruction Manual,* D. A. Calahan. *Ten dollars.*
- ☐ *A Summary of Engineering Research, 1964. No charge.*
- ☐ *Proceedings of the First Allerton Conference on Circuit and System Theory* (780 pages). *Ten dollars.*
- ☐ *Proceedings of the Second Allerton Conference on Circuit and System Theory* (914 pages). *Ten dollars.*

Send with remittance to Engineering Publications, 112 Civil Engineering Hall, University of Illinois, Urbana, Illinois 61803

AIR CONDITIONING REPORT AVAILABLE

Technical Report 8, *Comparative Performances of Year Around Air Conditioning in a Split-Level Residence,* summarizes a two-year investigation of comfort conditioning a split-level residence with ducted air systems. The residence was located in a geographical area which experiences approximately 6,000 degree days; thus the air distribution system and supply outlet locations were designed principally for heating, although summer cooling was of significant concern.

Data have been obtained to show the importance and need for seasonal rebalancing (winter to summer conditioning) when heating and cooling loads are not in the same proportion on each level of a dwelling. Air flow rates were also varied to determine the effects on the temperature balance, the conditioning equipment, and seasonal rebalancing.

In general, the results indicated that conventional conditioning equipment should provide acceptable year around comfort in a split-level residence, provided that design and operating criteria, specified by the authors, are employed. The charge for Technical Report 8 is $1.00 per copy. ◆

PEOPLE AND PLACES

A. B. Chilton, Associate Professor of Civil Engineering and of Nuclear Engineering, has been appointed to the Editorial Advisory Board of the journal *Nuclear Applications,* a publication of the American Nuclear Society.

N. M. Newmark, Head of the U of I Department of Civil Engineering, has contributed a chapter on structural engineering to a new book, *Listen to Leaders in Engineering,* published by Tupper and Love of Atlanta, and David McKay Company of New York.

Approximately thirty-five professional employees of the Corps of Engineers and other federal agencies have been selected to attend a **Water Planning Course** being conducted by the Department of Civil Engineering during the spring semester. The course emphasizes the synthesis of engineering, economic, sociologic, natural, legal, and policy aspects of water resources as applicable to the development of river basin plans.

The College of Engineering's annual **Open House** will be held March 12–13. All departments of the College will be open to the 15,000 visitors expected.

Dr. D. Alpert, Director of the Coordinated Science Laboratory, will become Dean of the U of I Graduate College next fall. He is currently on leave from the University, and **Dr. M. E. Van Valkenburg** is serving as acting director of CSL. ◆

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 6, NO. 3, MARCH 1965

In the order listed, this issue contains articles on the following subjects:

THE DIRT WE BREATHE . . .

Often the air in a room looks and feels clean until a ray of sunlight through a window reveals a sea of tiny particles floating about. Though seldom noticed, these particles (usually about .0005 inch in diameter) may be harmful to humans. Such air pollutants are by-products of urbanization and industrial development.

The replacement of coal and wood by gas and liquid hydrocarbon fuels has reduced the average size of air pollution particles to a hundredth of their former size. These small, carbon-rich particles are too small to be efficiently filtered out in the human nasal and upper respiratory passages and often lodge in the lungs, where they may cause respiratory diseases. This aspect of air pollution is under study by Professor I. Hayakawa of the University of Illinois Sanitary Engineering Laboratory.

Modern pollution control techniques and equipment such as artificial coagulation of pollutants, settling chambers, cyclones, filters, electrostatic precipitators, and liquid scrubbers are used to collect particles for study.

Present research focuses on two subjects: the coagulation of small aerosol particles (of the size most easily trapped in the lungs); and the viability of airborne bacteria and behavior of bacteria-destroying agents like those produced by combustion. It has been observed that a single airborne bacterium settling on a nutritive surface will grow into a colony visible to the naked eye in less than twenty-four hours.

Eventually an air-cleansing system using industrial waste detergent foam may be developed which will remove both pollutants and airborne bacteria. This process could be used for "clean rooms," the contaminant-free areas used in guided missile, electronics, pharmaceutical, and other modern industries for whom the distance between success and failure may be no bigger than a piece of dust. ◆

A CRYSTAL BALL IN SPACE

A University of Illinois engineer, Professor Howard W. Knoebel, has proposed that a spinning glass ball the size of a basketball be put into orbit around the earth to test one of Einstein's theories.

The idea was developed by the University's Coordinated Science Laboratory in a project sponsored by the National Aeronautics and Space Administration. The ball, spinning in friction-free space, would act as a gyroscope. Its axis would remain in a fixed direction. If Einstein's general theory of relativity is true, movement of the ball near the great mass of the earth should cause this axis to shift. Within a year the shift should be sufficient to be detected, if the satellite is not disturbed by micrometeorites.

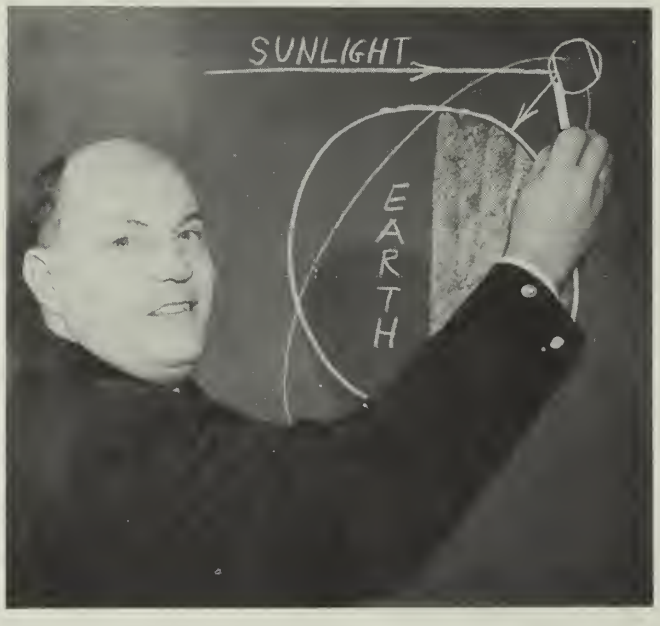
A mirror three inches in diameter across an axis end of the ball would flash the sun's rays toward earth in a narrow beam at dawn and at dusk for six weeks twice each year. Any change in the axis would shift the beam. From earth it would look like a short streaking flash from a bright star which could be seen only from an area about four miles wide.

Knoebel said that such a simple ball and mirror satellite, costing less than $200,000, would carry out the test more effectively than a multi-million dollar electronic satellite.

The idea of using a gyroscope in space to test the general theory of relativity which Einstein propounded in 1916 was suggested several years ago, but no gyroscope sufficiently precise was available. The U of I Coordinated Science Laboratory has since developed the most precise gyro-compass ever made. The heart of it is a free-spinning ball, supported by electrostatic forces (see *Outlook*, April, 1963). NASA asked the laboratory to study whether this instrument could be used in a satellite to make the test. University engineers under Knoebel's leadership developed the idea of using a ball alone with a mirror to report the direction of its axis.

The ball will be made of glass or similar ceramic material processed so that it will not be affected by stray magnetic or electric fields in space. It might be carried aloft with some other satellite and tossed into orbit 400 miles above the earth. Several such balls might be launched to check against each other and to determine any effects of the sun's heat, micrometeorites, or the wide-spread molecules of space gas.

When a launch is made, Knoebel plans to ask help of the public in spotting the ball. Though the general area where it might be seen will be predicted, only observation can determine the actual area. Photographs then can reveal the precise angle of the space-gyro's axis, of any changes in it, and whether or not Einstein was correct. ◆



Professor Howard W. Knoebel of the U of I Coordinated Science Laboratary, who hos proposed putting o spinning gloss boll the size af a basketboll inta orbit around the warld to check Einstein's general theory of relotivity, shaws haw a mirror on the oxis end of the boll would reflect sunlight and reveal whether the oxis shifts as the theory predicts.

WRINKLED EXPLOSIONS

The birth and short, violent life of the detonation wave — the fast-moving outside edge of an explosion — is being studied by Professor R. A. Strehlow of the University of Illinois Aeronautical and Astronautical Engineering Department.

Explosion study may not sound like a sport for the timid, but the danger in this case is slight. The detonation waves are contained within long, heavy metal tubes, and predetonation pressures within the tubes are reduced to a near vacuum, so that even the twenty-fold pressure rise of the ordinary detonation wave results in small maximum pressures.

But the reduced risk doesn't make detonation waves easy to see. Moving at almost 7,000 mph, and only 1 millimeter thick, a detonation wave is a highly transient phenomenon. It is also two-faced: in front is a strong shock wave (like those created by supersonic jets) which heats and ignites the explosive medium through which it travels, and behind is the equally speedy combustion front of the explosion. Special ultra-high-speed photographic techniques follow either the density changes or luminosity caused by the detonation wave to produce an image of the fleeting wave itself.

Of particular interest are the "wrinkles," the weaker transverse shock waves which move across the detonation wave's surface and which, according to Professor Strehlow, are essential in sustaining it. After fingerprinting these waves by passing them over smoke-blackened foil, his group analyzes wave size, shape, speed, and direction. From such data Dr. Strehlow has suggested and is testing a new mechanism for the propagation of detonation waves: using established principles of reaction kinetics and gas dynamics, he proved that smooth, one-dimensional detonation waves are unstable (by themselves they would fade and disappear). Now he hopes to show that the inherently stable transverse waves feed energy from the combustion region behind the wave front to the shock front in a manner which stabilizes the detonation wave.

Such a theory is of considerable interest to proponents of a promising new aircraft engine, the supersonic combustion ramjet ("scramjet"), which may boost the limits of engine efficiency by allowing combustion air to blast through the engine at supersonic speeds, instead of slowing, burning, and accelerating the air again as in existing jets. At high supersonic speeds combustion will have to take the form of a continuous explosion within the engine, and the success of the engine will largely depend on accurate knowledge of detonation waves. ◆

The University of Illinois radio direction finder uses 120 poles each 65 feet high in a 955-foot-diameter circle to support a reflective screen of 960 vertical wires. Around the outside of the screen are 120 antenna units whose supports are barely visible in the picture. Each antenna is 16 feet high and is connected by a 500-foot-long pressurized coaxial cable to switching devices and radio receivers in the building at the center.

WHAT TO DO WITH A RADIO SIGNAL IF YOU DON'T KNOW WHERE IT'S BEEN

Changes in the ionosphere, the atmospheric "radio mirror" which encircles the earth many miles above its surface, are being studied from the University of Illinois with one of the world's largest and most precise radio direction finding systems. The program is directed by Electrical Engineering Professor E. C. Hayden.

In seven years of work, U of I engineers have greatly increased receiver sensitivity and directional accuracy, have reduced markedly the effect of interfering stations on the same operating frequency, and have developed the system as a research tool for probing the ionosphere. They have improved the direction finder's accuracy so that the instrument is no longer a limiting factor. Their problem now is to understand the deviousness of the path a signal may take due to ionospheric effects.

Though the instrument is accurate to within half a degree in showing the direction from which a signal arrives, ionospheric irregularities may cause signals to be bent as much as 90 degrees (once transmissions from Washington, D.C., came to Illinois from the direction of the North Pole). These irregularities are influenced by many factors; the eleven-year sunspot cycle, day-to-night changes, and moment-to-moment variations in the ionosphere are just a few.

The radio direction finder, located on a forty-acre site eight miles west of the campus, consists of a 993-foot-diameter circular array of 120 antennas surrounding a wire screen 65 feet tall. Through a switching device the antennas are successively connected to a receiver so that reception is scanned from all around the horizon as often as 900 times a minute. Information is displayed on a cathode ray tube similar to a radar scope. It can also be recorded on teletype tape for analysis by computer. The system is based on the Wullenweber radio direction finder developed in Germany during World War II.

Radio direction finders are regularly used in navigation to locate the point of origin of radio signals and thereby the location of a ship or aircraft. In wartime they may indicate the source of enemy transmissions. A thorough understanding of ionosphere-induced inaccuracies will help provide more reliable radio communications and more precise direction finding. ◆

HIGH-STRENGTH BOLTS CHANGE STEEL FABRICATION METHODS

Riveting has been used since the earliest metal structures and is considered a reliable and effective method of connection. However, not since steel replaced wrought iron and cast iron members in structures has any innovation had so great and rapid an impact on structural fabrica-

tion as the introduction of high-strength bolts. In 1964 more than 50 million high-strength bolts were used in various types of structures in this country.

This new technique of structural fastening, along with the need for additional knowledge in all areas of structural connections, led to the formation of the Research Council on Riveted and Bolted Structural Joints in 1946. By 1951, the first nationally accepted specification for high-strength bolts was prepared by the council with the assistance of civil engineers from the University of Illinois.

All types of major structures have employed high-strength bolts for shop and field connections, including the Vertical Assembly Building at Cape Kennedy where moon rockets will be assembled. This building will be the world's largest when completed and will have doors 456 feet high, as well as many other unique features. Among the outstanding examples of structures using the bolts have been the Pan American Building in New York City, which had four and one-half million high-strength bolts, and the Verrazano Narrows Bridge, which had three million high-strength bolts in the two towers alone. It has been estimated that in a typical year one-half to one million high-strength bolts are used just on bridges within the state of Illinois.

There are a number of advantages to the use of high-strength bolts: reduced cost and time required for construction due to speed of installation and smaller size of crews; smaller joints, because of greater fastener strength; less noise than riveting; ease of dismantling for repairs or alterations; improved stiffness and greater resistance to repeated loads. Substantial savings are realized by many industries where repairs and alterations must be made to steel structures. Previously, the need to move considerable equipment and a large work crew from site to site to re-drive a few rivets made such repair work extremely expensive. Now high-strength bolts can be installed at relatively small costs.

The University of Illinois has been a leader in this research since 1947, and these research studies have contributed to the knowledge and confidence which has been placed in high-strength bolts. Professor W. H. Munse from the University of Illinois has been involved in this research since 1947, and Dr. E. Chesson, Jr., has been the supervisor for the research programs on these fasteners since 1953. Because of their experience these two staff members have served on the Specification Committee of the Research Council for Riveted and Bolted Structural Joints, and have participated in the writing of the recent revisions of the Council's specifications. ◆

PEOPLE AND PLACES

Two University of Illinois professors, **John Bardeen,** professor of electrical engineering and physics and a member of the Center for Advanced Study, and **Nathan Newmark,** head of the Department of Civil Engineering, were among the first thirteen recipients of the Order of Lincoln. As recipients of the awards, the men have been nominated for permanent membership in the Lincoln Academy of Illinois, recently established by Governor Otto Kerner to encourage and recognize outstanding contributions made by Illinois citizens.

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P 4

ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 6, NO. 4, APRIL, 1965

In the order listed, this issue contains articles on the following subjects:

. . . AND A TWIST OF LIME

Lime-stabilized soils have been used as construction materials since the days of the Roman Empire. However, it was not until the end of World War II that lime was widely used as a soil stabilizer for highway construction across the country, and it has never been used extensively in Illinois. Researchers in the University of Illinois Civil Engineering Department are now trying to determine if lime can be economically and effectively utilized to stabilize Illinois soils.

When this project was initiated in 1958, there was little information available which could be used to determine if a particular soil could be satisfactorily stabilized with lime. Only recently has the nature of the lime-soil reactions and the factors influencing them been investigated from a scientific viewpoint. In general, lime additions of three to ten per cent by weight of soil markedly influence the engineering properties of the soil. The lime reacts with the soil constituents and generally affects a reduction in soil plasticity, an improvement of workability characteristics, and an increase in strength and durability. The extent to which the lime improves the engineering properties depends on the nature of the soil.

Representative soils from throughout Illinois have been sampled and treated with lime in order to determine the effect on their engineering properties. Extensive analysis of the natural soils has indicated that certain soil chemical and mineralogical properties significantly influence the capability of a soil to react with lime and produce an improved engineering material. Criteria and techniques to assess the probable lime-reactivity of a soil are being developed that will enable the engineer to know when and how lime can be used with any given Illinois soil to make it stronger and more durable. The research, which is sponsored jointly by the Illinois Division of Highways and the U.S. Bureau of Public Roads, is directed by Marshall Thompson of the Civil Engineering Department. ◆

ENGINEERING DEGREES AND ENROLLMENTS RISING

According to the February, 1965, issue of the *Journal of Engineering Education,* the numbers of degrees in engineering awarded at all levels by U. S. institutions increased significantly during 1963-64. The increase over last year in engineering degrees granted is: doctor's — up 22.9 per cent; master's — up 12.4 per cent; and bachelor's — up 5.3 per cent. Freshman enrollments in engineering for all institutions are up 12.1 per cent over last year, and the increases of students enrolled at all levels are significantly higher.

These increases in engineering enrollment and degrees are being reflected at the University of Illinois. In 1963-64, Illinois ranked second in the country in the number of Ph.D.'s awarded (131 — up 62 per cent); fifth in number of master's degrees granted (331 — up 1.5 per cent); and second in number of bachelor's degrees (818 — up 5 per cent). ◆

A PERFECT WHISKER

A "red whisker" is helping Electrical Engineering Department researchers at the University of Illinois understand the chemical compounds that make up many important semiconductor devices.

This is not an ordinary whisker, however. This "whisker" is a structurally flawless, needle-like crystal of gallium arsenide-phosphide, one of the prime components of semiconductor lasers (see *Outlook,* December, 1963). Less than ¼ inch long, the transparent orange-red crystal

is completely free from the structural defects in crystalline arrangement that permeate ordinary metals. As a result the whisker has nearly perfect mechanical properties — amazing strength, for example — and provides an ideal specimen for studying crystal growth and defect development processes.

The picture above gives a clue to how the crystal was grown. A small molten alloy ball (at far left), surrounded by an atmosphere of vaporized gallium arsenide-phosphide, absorbs the chemical compound until it is supersaturated. The excess compound is seeded from the alloy in the form of a solid needle, which "grows," carrying the still-molten alloy ball on its tip.

Neither the vapor-liquid-solid (VLS) process nor pure metal crystals are new, but the Electrical Engineering Department's red whisker is. It represents the first-known instance of production of a compound crystal by the VLS mechanism, and the first time a large, structurally perfect single whisker of a compound has been grown. Professor N. Holonyak, Jr., who directs this research, ought to be proud: a man's first whisker is an important event. ◆

REVIEW OF CONCRETE FATIGUE RESEARCH

A Critical Review of Research on Fatigue of Plain Concrete, by John W. Murdock, presents a concise and orderly evaluation of investigations of the fatigue behavior of plain concrete covering the period since 1898. The review assesses the present state and limitations of the knowledge in this field, and indicates areas of potentially fruitful research.

Investigations of plain concrete fatigue under both axial and bending loads are reported, and both the strengths and weaknesses of the investigations are noted.

The review has been published as Engineering Experiment Station Bulletin No. 475, and is available for $1.50 from the Engineering Publications Office. ◆

GUIDANCE BOOKLET, *CAREERS,* REVISED

The guidance booklet, *Careers in Engineering,* has been revised and is being published as two separate booklets, one for students and one for counselors. The student handbook (still entitled *Careers in Engineering*) is now available without charge from the Engineering Publications Office; the counselors' booklet (entitled *What Students Want to Know About Careers in Engineering*) will be published later in the year and will also be distributed without cost.

The revised *Careers in Engineering* is designed as an aid for high school and pre-high school students who are considering college and career possibilities. It stresses the college preparatory course for college-bound students regardless of their choice of careers. *Careers in Engineering* also gives information concerning the University of Illinois College of Engineering, including entrance requirements, degree programs, extracurricular activities, and the Chicago Circle Campus.

What Students Want to Know About Careers in Engineering will be a detailed guidebook written for teachers, counselors, and parents. It will give specific information which will be useful in discussing engineering as a career with students who show interest. The publication will be announced in *Outlook.* ◆

WUERKER BULLETIN PUBLISHED

During the spring of 1960, a gravity and magnetic survey was made in Illinois. The data obtained from that survey are contained in Engineering Experiment Station Bulletin No. 474, *Gravimetric and Magnetic Observations Along the 40th Parallel in the State of Illinois,* by R. G. Wuerker. The report also gives an interpretation in terms of a gravity and magnetic anomaly profile along the 40th parallel across the state of Illinois.

The survey was made by the late Rudolph G. Wuerker. The material was compiled posthumously from Professor Wuerker's notes by H. E. Gaudette, Research Associate in Geology, and A. E. Scheidegger, Professor of Petrophysics. Bulletin No. 474 costs $1.00 and may be obtained by writing the Engineering Publications Office. ◆

REPORT OF POZZOLANIC PAVEMENT STUDY AVAILABLE

Bulletin No. 473, *Pozzolanic Pavements,* by Harold L. Ahlberg and Ernest J. Barenberg, is now available from the Engineering Publications Office. The Bulletin reports a broad research program on lime-pozzolan-aggregate mixtures for use as base course materials in highway pavements. A total of thirty-four pavements were tested under dynamic loads and eight under static loads on the University of Illinois Pavement Test Track. Crushed

stone pavements were also tested for comparative purposes. Through the correlation of vast amounts of substantiating data taken over a five-year period, a rational method for determining the load-carrying capacity of pozzolanic slabs and for specifying the thickness of pozzolanic pavements was developed. The 130-page Bulletin can be obtained for $3.00 by writing Engineering Publications Office, 112 Civil Engineering Hall, Urbana, Illinois 61803. ◆

A REAL-WORLD LABORATORY COURSE

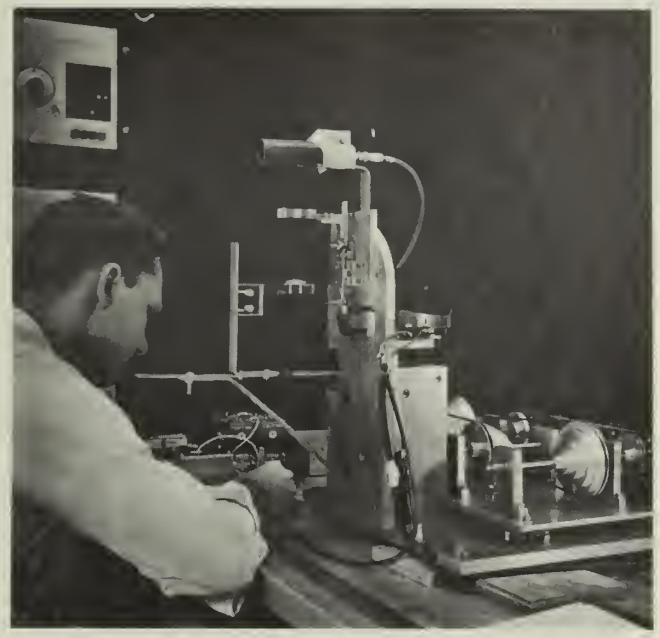
A new laboratory course offered by the U of I Physics Department gives undergraduates an introduction to some of the modern equipment and sophisticated techniques that they will face in research work after graduation. Because most modern experiments require expensive equipment and constant updating of laboratories, they are often not a part of an undergraduate's education. Recently, however, the National Science Foundation gave $25,000 and the University gave $45,000 to outfit the first laboratory for undergraduates at the U of I to do experiments closely related to current physics research. Equipment salvaged from completed or abandoned research projects has helped make optimum use of the money.

Last semester students studied the properties of superconductors, the distribution of electrons in solids, spectroscopic properties of various materials, lasers, and other topics of current interest to today's researchers. The experiments require that a student use his own ingenuity. The instructions give him a good idea of the equipment necessary, a detailed statement of the problem, and a few suggestions on how to get started. The rest of the myriad of information he needs must be found in the library or by trial and error in the lab.

Since the problems are complex and modern, the lab work approaches "real-world" situations. In many cases the equipment as the students find it is not satisfactory for what they want to do. It has not been built and adapted precisely to the experiment as in more conventional labs. They find out, maybe for the first time, that setting up the experiment often takes longer than running it.

The lab is organized on a two-semester basis. The first semester (Physics 303) is devoted to an approximately six-week experiment in nuclear physics and one or two other experiments of the student's choice. The nuclear physics experiment is standardized for the entire class, but the students progress at their own rate.

After carrying out the prescribed project and preparing a report of their work, they go on to more independent experimentation. They work individually or in pairs and



An undergraduote student in the Physics Deportment's Modern Experimentol Physics Labaratary is studying the microscopic mognetic fields thot exist in iron by observing the recail energy of atoms. The loboratary course is designed ta encourage the students to use their own ingenuity to solve the problems they encaunter in the laboratory.

are not burdened with many time-consuming reports or exams. They are graded on their performance in lab, a half-hour presentation of their project at a seminar, and a final oral exam. The oral exam is the real test of their understanding of their experiment and of the results obtained.

The second semester (Physics 304) has an even less structured agenda. The students work individually, generally on one project all semester. Grades are given according to the instructor's evaluation of the student's understanding of his work and of the way he did it. No final exam is necessary since the students work closely with the instructors all semester.

Although the students often find themselves floundering with problems that even the instructor may not have the answer for, they have time in the two four-hour labs each week to reflect on the problem and try different solutions. When they finally get a workable answer they have something not often enough achieved by undergraduates — the solution to a real problem obtained through their own ingenuity and library research. ◆

CARBURETORS WITH A LEAN BUT NOT HUNGRY LOOK

A gallon of gasoline may soon look bigger to thousands of farmers across the United States, thanks to a fuel-saving device recently tested by University of Illinois Agricultural Engineers. By modifying the carburetor and ignition system of a standard gasoline tractor, researchers under the direction of Professor J. A. Weber

have made possible savings of 10 to 15 per cent for tractors operating at part loads, without loss of maximum horsepower.

The new modifications follow a trend established by automotive manufacturers. Tractor carburetors have traditionally had just one fuel opening ("jet") which was adjusted for best performance at full engine power, with the result that part-load fuel mixtures were richer than necessary. Studies by the Agricultural Engineering Department indicated, however, that the average load on farm tractors is 50 per cent of maximum horsepower.

The researchers' answer was the same as that developed by auto manufacturers: add another carburetor jet adjusted for lean, economical operation at low power, and open both jets only when high engine power is required. Efficient burning of this varying mixture requires that the ignition timing be variable, so the Illinois agricultural engineers added a manifold-pressure-operated spark advance similar to those used in cars.

Field tests of an 80-hp tractor with these modifications indicated fuel savings of up to 15 per cent during corn cultivation, with smaller savings for operations requiring more power. Professor Weber estimates savings up to $350 for the average farmer during the life of a tractor.

Several companies provided equipment and technical help for this research, including Marvel-Schebler, Delco-Remy, Deere and Company, and Allis Chalmers. Part of the financial support was provided by FS Services, Inc., of Bloomington, Illinois. One tractor manufacturer has already included the two-jet carburetion system in a new tractor model, and other manufacturers are testing new designs that increase the part-load efficiency of their tractors. Probably this or some similar fuel saving device will be a feature of most gasoline tractors that appear in the future. ◆

PEOPLE AND PLACES

Dr. H. M. Karara, Associate Professor of Civil Engineering at the U of I, has been appointed Chairman of the Research Committee of the American Society of Photogrammetry.

Professor P. A. Beck has been installed as a Fellow of the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

Dr. N. M. Newmark, Head of the U of I Department of Civil Engineering, gave the Fifth Rankine Lecture in London. He was the second American to give this lecture, an annual address given by a person of distinction in the field of soil mechanics.

Professor N. Holonyak of the U of I Electrical Engineering Department is one of four authors of a new book by Prentice-Hall, Inc., Englewood Cliffs, New Jersey, entitled *Semiconductor Controlled Rectifiers: Principles and Application of p-n-p-n Devices.* The co-authors, F. Gentry, F. W. Gutzwiler, and E. Von Zastrow, are all with the General Electric Company.

Dr. S. J. Fenves, Associate Professor of Civil Engineering and Research Associate Professor, Coordinated Science Laboratory, was awarded a Walter Huber Research Prize in March by the American Society of Civil Engineers.

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ENGINEERING OUTLOOK

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 6, NO. 5, MAY, 1965

In the order listed, this issue contains articles on the following subjects:

YOU SHOULD LIVE SO LONG

If you could live for the next two centuries, you would, among other things, observe as much deterioration of our streets and highways as U of I civil engineers are going to see over the next year. They are going to accelerate the damage caused to bridge floors and streets by weather and de-icing chemicals by building a special chamber in which they can create an environment that will make the "winter of '76" look like April in Paris.

The chamber will be an insulated room twelve feet square and seven feet high where six-foot by three-foot sections of bridge floors will be frozen and thawed, soaked and dried, and dosed with salt and other chemicals while being simultaneously subjected to constant or repeated loads simulating traffic.

This research program, which is sponsored by the Highway Research Board, Washington, D. C., is directed by C. E. Kesler, Professor of Theoretical and Applied Mechanics. Professor Kesler said the new chamber in Talbot Laboratory will be used to learn whether de-icing chemicals and the loads of traffic combine to form cracks that provide access channels for water which will weaken the concrete. He said highway slabs will also be tested, and he is planning to place slabs outdoors to compare the effects of nature's weather conditioning with the effects of conditions he will establish in his laboratory.

We're betting that he's going to win the contest. ◆

CONCRETE BULLETINS PUBLISHED

A Critical Review of Research on Fatigue of Plain Concrete, by John W. Murdock, summarizes research in this area, assesses the value of the studies summarized, and suggests areas of potentially fruitful research.

The review, Engineering Experiment Station Bulletin No. 475, covers both basic and applied research, and surveys studies of plain concrete subjected to axial and bending loads. The Bulletin is available for $1.50 from the Engineering Publications Office.

Rheology of Concrete: A Review of Research. A comprehensive review of the present knowledge of the rheological behavior of concrete and the various hypotheses advanced by numerous investigators is presented in Engineering Experiment Station Bulletin 476, by Professor C. E. Kesler and Mr. Iqbal Ali of the University of Illinois. Their extensive bibliography contains over 207 references dating back to the first decade of this century.

The authors consolidate opinions on factors affecting creep, the relation of creep to structural behavior, the origins of creep, and the rheological models for creep which have been presented by various investigators. Bulletin 476 costs $2.00 per copy.

Ultimate Design of Prestressed Concrete Beams. A general method of analysis of prestressed concrete beams at ultimate conditions is presented in Engineering Experiment Station Bulletin 478, by Professor N. Khachaturian and Mr. German Gurfinkel, both registered structural engineers in the Department of Civil Engineering.

Equations for the determination of ultimate moment are derived and simplified expressions are presented for ultimate moment for use in design. A method is presented by which prestressed concrete beams can be designed on the basis of strength and ductility. Structural engineers, as well as specification writers, will benefit from this publication and the clarification of the Provisions of the American Concrete Institute Building Code. The Bulletin may be obtained for $2.50 per copy. ◆

He sees it this way . . . . . .

but the machine sees it this way.

Professors C. M. Wayman and A. J. Morton (shawn in phota) af the U af I Department af Mining, Metallurgy, and Petraleum Engineering are conducting research an the effects of ultra-high quenching rates an iran allays. The quenching, at rates as high as 75,000° C/sec., is accomplished by discharging helium into the vacuum chamber through a supersonic nazzle. The changes in the internal structure af the iran allay are "seen" and displayed by the metallagraph shawn in the lawer phatagraph.

NEW PUBLICATION CLASSIFIES ILLINOIS SOILS

Nine Illinois counties provided the sites for an extensive program of classification of surface soils reported in *Engineering Index Properties of Some Surficial Soils in Illinois,* by Thomas K. Liu and Thomas H. Thornburn. Samples (of Humic-Glay soils) from 120 test borings were subjected to statistical analysis of six index properties; liquid limit, plasticity index, percentages passing sieve numbers 20, 40, and 200, and per cent clay $< 2\ \mu$.

The publication, Engineering Experiment Station Bulletin No. 477, is available for $2.50 from the Engineering Publications Office. ◆

ENGINEERING TECHNICIAN TRAINING PROGRAM

Because of a severe shortage of trained engineering technicians, the University of Illinois departments of Civil Engineering, General Engineering, and Mathematics will conduct an eleven-week Engineering Technician Training Program beginning June 14 for one hundred and fifty high school students on the Urbana campus. Another group of twenty-five students will take similar training at the Chicago Circle campus.

This technician program will provide training for selected high school students who are interested in working for the Division of Highways. Many practical subjects are given such as engineering drawing, general surveying, and highway materials. In addition, technical subjects such as mathematics are covered to give the students a better understanding of engineering technology. Students are selected for attendance based on their high school grades, scores on exams taken through the University, and interviews by personnel of the Division of Highways. ◆

THREE GUIDANCE BOOKLETS AVAILABLE

Three new guidance publications for high school counselors and students are available free from the Engineering Publications Office.

What Students Want to Know About Careers in Engineering is a detailed guidebook for teachers, counselors, and parents. It gives specific information which will be useful in discussing engineering careers with students.

A second publication, the revised *Careers in Engineering* (see *Outlook,* April, 1965), is designed as an aid for high school and pre-high school students who are considering college and career possibilities.

Computers, Computing and Careers, prepared by the Department of Computer Science, describes briefly the history and uses of computers, and career opportunities in computer science. ◆

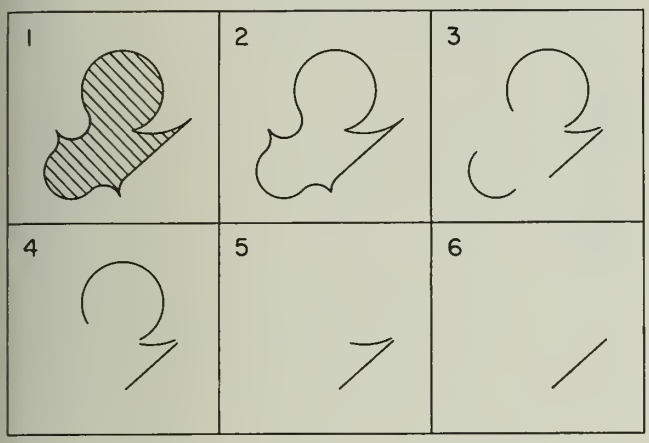
WHAT'S IN A SEPTENDECAGON?

Seventeen corners and seventeen sides, naturally. Researcher John Russell might respond differently, though — he might ask his machine to figure out the answer.

Mr. Russell is a member of the University of Illinois Electrical Engineering Department's Biological Computer Laboratory, the same group which developed the Numa-Rete, the "eye" which counts discrete objects simultaneously (see *Outlook,* December, 1960). His current project is a machine to imitate (and hopefully improve upon) man's ability to perceive two-dimensional forms.

The operating principle of the device is the same as that indicated by recent experiments to be the human perceptive process: features of a pattern, rather than the total pattern itself, are recognized and related.

The example below shows how the process works. Is there a straight line in the figures?



In the series of operations pictured, the machine first reduces the form to an outline, then removes the curved segments from the outline (sharpest curves, the corners, are deleted first), and finally leaves visible only the straight line segment. In similar operations the device will detect curves of specified radius, corners, and other features of two-dimensional images.

The value of this feature-finding ability, while not necessarily apparent, is considerable. Interpretation of photo reconnaissance pictures would be speeded by such a machine, able to detect man-made objects — those with straight lines — in the hundreds of photographs made on a typical mission. Initial inspection of signatures and endorsements on checks and other documents could be made by machine, lightening the work of banks. Computers could at last be equipped to "read" printing in many sizes and shapes, from many sources, enhancing their flexibility and usefulness. No one knows how many uses the image processer might have. John Russell isn't making any estimates — he's still asking his machine about the septen . . . sept . . . sep. . . . ◆

COLLEGE OF ENGINEERING HONORS ALUMNI AND STUDENTS

Six College of Engineering alumni were honored for distinguished service in engineering, and four senior students for high scholastic achievements in an awards convocation held on May 4, 1965.

Each of the alumni received a medal designed by Frank Gallo, former staff member of the U of I Department of Art. The recipients were: Gene Lee Armstrong, Director of Missiles and Space Systems, General Dynamics Corporation, New York; Louis Clifford Goad, Executive Vice President, General Motors Corporation, Detroit, Michigan; Dr. George Kenneth Green, Chairman of the Accelerator Department, Brookhaven National Laboratory, Upton, Long Island, New York; Ernest Christian Hartmann, Director of Research, Aluminum Company of America, New Kensington, Pennsylvania; Professor Herbert R. Lissner, Chairman, Department of Engineering Mechanics, and Coordinator, Biomechanics Research Center, Wayne State University, Detroit, Michigan; and Maurice Northrop Quade, Senior Partner, Parsons, Brinckerhoff, Quade and Douglas, New York.

The four special awards of the College of Engineering are granted annually to undergraduate students through College-wide competition. This year the Hamilton

Watch Company Award was presented to Donald John Render, senior in Mechanical Engineering; the Honeywell Award, to Allan Robert Evans, senior in Physics; the Harvey H. Jordan Award, to Glenn F. VanBlaricum, Jr., senior in Electrical Engineering; and the Lisle Abbott Rose Memorial Award, to Gary Earle Gladding, senior in Physics.

The awards recipients and their guests were honored at a dinner in the Illini Union Building; presentation of the awards was made by College of Engineering Dean W. L. Everitt. ◆

ANTENNA RESEARCH PROCEEDINGS PUBLISHED

The *Proceedings of the Applications Forum on Antenna Research* may now be purchased from the Engineering Publications Office. The Antenna Forum, held in January, 1964, brought together top men in antenna research from all over the United States from industrial, government, and university laboratories. A total of fifteen lectures was given on frequency-independent antennas, data-processing antennas, antennas in anisotropic and moving media, and aperiodic antenna arrays.

A group of seven speakers from other university and industrial laboratories and five professors from the U of I Antenna Laboratory presented four days of comprehensive lectures on these four phases of modern antenna research.

The *Proceedings* consists of 611 pages of text, including 300 figures prepared by the speakers. Professor Paul E. Mayes, U of I Antenna Laboratory, was Forum Director and editor of the volume. The *Proceedings* costs $5.00. ◆

PEOPLE AND PLACES

A retired University of Illinois professor, **A. I. Andrews,** former Head of the Ceramic Engineering Department, received the 1965 Greaves-Walker Award of the National Institute of Ceramic Engineers at the Institute's annual meeting in Philadelphia on May 2. The award honors members who have rendered outstanding service to ceramic engineering and have exemplified the aims, ideals, and purposes of the Institute in their lives and careers.

Ralph C. Hay, University of Illinois Professor of Agricultural Engineering, has been elected to the honorary grade of fellow in the American Society of Agricultural Engineers, an organization with which he has been affiliated since 1934.

Professor **Nathan M. Newmark,** Head, University of Illinois Department of Civil Engineering, and Professor **Mete A. Sozen** of the department spoke at the symposium on Dynamics of Structures with Applications to Earth Resistance of Tall Buildings, held April 27–29. Leading engineers of the country attended the symposium in Washington, D. C., during the first annual meeting of the National Academy of Engineering.

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 6, NO. 6, JUNE 1966

In the order listed, this issue contains articles on the following subjects:

HUM A FEW BARS AND HE'LL FAKE IT

Musical tones different from those of any existing instrument may come from research at the University of Illinois, where Professor James W. Beauchamp of the Department of Electrical Engineering is undertaking a detailed and precise mathematical analysis of musical tones. He will use high-speed electronic computers and the electronic facilities of the University's School of Music. The analysis will be important to musicians, composers, teachers, engineers, and manufacturers.

Beauchamp will seek answers to these and other questions: What distinguishes tones produced by different instruments? How are these affected by pitch, loudness, playing style, and performer? What distinguishes good from poor tone quality? And what properties interest the human ear? Answers obtained by mathematically taking musical tones apart could provide a way to mathematically compose music with completely new tone qualities.

The Magnavox Company will support this research with $20,000 a year for three years and provide an electronic organ for use in the study. The firm has provided $10,000 a year for the past three years for music research at Illinois under Professor Lejaren A. Hiller, Jr., of the School of Music. This pioneer in the application of electronics to music has developed a unique center for study of electronic and computer music and analytical studies of sound. Related work in this area was reported in the November issue of *Outlook*.

Hiller's use of the University's Illiac I and IBM 7094 computers for musical composition is well known, but he has also performed extensive research in musical acoustics and experimental music. Beauchamp has worked with him for several years, during which time Beauchamp invented a new electronic device called the Harmonic Tone Generator which provides means to add and individually control overtones of a harmonic series to form a complex musical tone. ◆

COLD CUTS

The bounce made rubber famous, but it also made it exasperatingly hard to work with. Cutting rubber parts, for instance, is ordinarily a slow, difficult, imprecise operation. Now a study at the University of Illinois has shown that rubber can be machined like metal quite accurately if it is first cooled to supercold temperatures.

Professor K. J. Trigger of the Department of Mechanical and Industrial Engineering developed this cold machining technique to cut rubber printing plates. Such plates are used for printing on hard, grained, or rough surfaces where conventional type and etchings would not hold up. These rubber plates are presently carved by hand at room temperature. Total time per plate for this technique is three hours, and the work must be done by skilled craftsmen. The new technique could cut the time by two thirds, and one man with a little experience could keep several machines running simultaneously.

Professor Trigger first tested this technique by taking a rubber mat to the refrigeration room of a local dairy; after the mat was cold enough to be brittle, he drew a cutting tool across its surface. The chip produced indicated that the cooled material could be machined on a lathe.

Next, a special lathe normally used to engrave plastic printing plates was loaned by Graphic Electronics of La Salle, Illinois. This lathe, which automatically copies a black-on-white drawing of the image to be engraved, was adapted to the cold-cutting process by adding a liquid-nitrogen cooling device.

Currently Werner Diehl, a graduate assistant in Professor Trigger's group, is investigating the machining properties of various types of rubber cooled below the point at which it grows brittle. With this low-temperature information, the best material for the cold machining process can be selected.

If this technique seems unusual, Professor Trigger's latest idea is even more bizarre. He plans to replace the lathe's standard cutting tool with an air-driven burr like the ones used by dentists, in the hope that this high-speed tool will cut more smoothly and deeply. Apparently the main prerequisite to solving rubber problems is to have an elastic imagination. ◆

TUNNEL VISION GETS BETTER

The first flight (and the second, and perhaps the next few hundred) of any modern aircraft or missile does not involve test-pilot heroics or a dramatic takeoff from a secret airfield. Far more likely, the vehicle will fly first in miniature inside a wind tunnel, with an engineer at the controls.

But with faster airplanes come faster tunnels — and bigger test problems. No longer are comparative breezes of a few hundred miles per hour adequate; most modern wind tunnel tests involve blasting jets of gas at infernal temperatures. Accurate analysis of the speed and density of the gas during such flight simulations is difficult indeed.

A University of Illinois researcher may have developed an improved way to make these measurements. Professor J. L. Loth of the Department of Aeronautical and Astronautical Engineering has designed and tested a velocity and density probe which can tell the operator just what is happening inside a high-velocity wind tunnel.

The instrument, which is water cooled to keep it from burning in the 20,000-degree heat, uses the innovation of trapping part of the speeding gas and, from measurements of the mass, momentum, and energy content of the sample, allows the researcher to determine the exact conditions under which the test model is "flying."

The design of the probe was complicated by the fact that it has to endure destructive heating, must "swallow" the supersonic gas sample, and has to be small enough not to block the main gas flow.

The searing exhaust of a plasma jet creates a pattern of shock waves and turbulence from the nose of this special wind tunnel velocity and density probe. The instrument was designed by U of I Aeronautical Engineering Professor J. L. Loth to provide information on tests conducted at many times the speed of sound.

Later this year the probe will be added to the instrumentation of the University's new hypersonic wind tunnel, which is capable of test speeds up to twelve times the speed of sound. From facilities like this will come the knowledge engineers need to cope with the blazing speeds of tomorrow's travel. ◆

A DEEP DISCUSSION

Pioneers in the new field of marine soil mechanics met May 1-4 at the University of Illinois for the world's first Research Conference on Marine Geotechnique. Thirty scientists, including seven from foreign countries, took part in the conference at Allerton House, the U of I conference center. Present were almost all the men today engaged in the field of marine soil mechanics, which began little more than a decade ago.

While less is known about the bottom of the ocean than about the surface of the moon, knowledge of the strength of the ocean floor is essential for establishing undersea structures where men may live for long periods of time, for offshore oil drilling or mineral recovery, for pipelines, marine telephone cables, and safety of submarines which may wish to rest on the bottom.

The conference was sponsored by the University of Illinois and the Institute for Oceanography of the new Environmental Science Services Administration in the U.S. Department of Commerce. Professor Adrian F. Richards of the Departments of Geology and Civil Engineering organized the meeting. He was assisted by P. Wyman Harrison of the Institute for Oceanography's Land and Sea Interaction Laboratory at Norfolk, Virginia.

Richards, who recently came to Illinois, is developing a comprehensive laboratory, reported in the May issue of *Outlook,* to study marine soil mechanics as part of one of the most modern laboratories for marine sedimentology in the country. This project is in cooperation with the U.S. Institute of Oceanography, Office of Naval Research, Navy Bureau of Yards and Docks, and the National Science Foundation.

The University of Illinois, internationally known for research in soil mechanics on land, has extended its work to the sea bottom. Though the University is far from deep water, it is considered the birthplace of submarine geology through the investigations of Professor Francis P. Shepard while he was on the U of I staff from 1922 to 1945. ◆

THEY'RE IN HOT WATER

Archimedes was taking a bath when the principle of buoyancy occurred to him, and he shouted "Eureka!" Today, at the University of Illinois, volunteers are soaking in baths to study another principle — that of heat-induced sweating. Professor B. A. Hertig of the Mechanical and Industrial Engineering Department, in charge of this investigation, hopes to learn more about the physiology of sweating and the various conditions which affect perspiration rates.

Results of this study, conducted in the Physical Environment Laboratory, indicate a definite relationship between inhibition of sweating and the amount of moisture on the surface of the skin. When the test subject is immersed to his neck in a hot bath for several hours, his perspiration rate will increase for a time and then begin to decline. Perspiration rates appear to be dependent on immersion time as well as bath temperature. While tests in the past have attempted to explain this phenomenon in terms of sweat gland fatigue or decline in moisture content of the body, these explanations don't hold water under the conditions of the present study.

Professor Hertig's tests have involved a limited number of subjects, but the theory that moisture on the skin impedes perspiration has been borne out. Other tests show that subjects who have been acclimated to heat before entering the bath begin perspiring at a lower temperature in the bath than those who are unacclimated. Results also indicate that immersion in brine (10 to 15 per cent salt by weight) will prevent decline in perspiration.

Future tests may involve baths of silicone oil. In this way the moisture lost by the subject could be measured directly, since water doesn't mix with this oil. Current tests in water baths require that the subject be weighed at periodic intervals during the tests and corrections made for water consumed during his time in the bath.

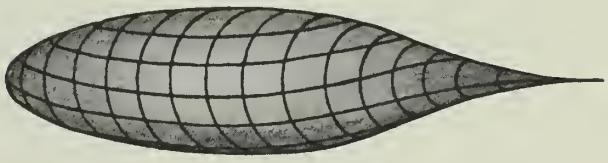
A better understanding of the phenomenon of sweating is important in situations where water supply is a problem, as in military operations and space flights. And when the mechanisms involved in sweating become clear, perhaps Professor Hertig can throw in the towel. ◆

WILL AUTOMATION DISPLACE GIRL-WATCHERS?

Men's preferences about shapes sometimes differ, but at the University of Illinois a researcher is settling questions of that kind scientifically — with a computer. Professor Will J. Worley of the Department of Theoretical and Applied Mechanics is directing a study of a special family of geometric shapes for the National Aeronautics and Space Administration, sponsor of the research.

The shapes, which find use in structural shells for fuel tanks, aircraft components, ships, and space craft, are derived from equations only slightly different from those used to plot ordinary ellipses. Although studied as early as the 1830's by Peter Dirichlet, a famous German mathematician, the equations lay essentially dormant for more than 100 years until the digital computer made their extended use practical. Now Professor Morris Stern and Dr. Han-chung Wang have compared these shell shapes, so that designers will be able to choose precisely the proper contours for a variety of applications. For a rocket fuel tank required to fit into a compartment of fixed dimensions, for example, an engineer might consult their results to help him select the tank shape with the best combination of weight, capacity, and strength.

Somewhat reassuringly, the computer has so far only looked at these relatively simple configurations. It seems unlikely that it could influence anyone's thinking about a *really* interesting shape, anyway. ◆



This streamlined shape is ane passibility amang a family af special shell shapes under a camputer investigatian directed by U af I Prafessar Will J. Warley. The shells, whase praperties he is tabulating, might be useful as fuel tanks, submarine hulls, and ather vessels.

NEWMARK NAMED TO NATIONAL ACADEMY OF SCIENCES

Election of Professor Nathan M. Newmark, Head of the Department of Civil Engineering, to the National Academy of Sciences, brings to 19 the number of University of Illinois faculty members honored by selection as America's foremost scientists in their fields. Among them is Professor Frederick Seitz, University of Illinois physicist, who is president of the Academy.

Newmark is also a founding member of the National Academy of Engineering, recently established companion organization to the National Academy of Sciences, in which the University of Illinois has three members.

Newmark's career has been devoted to research and instruction in structural engineering. The recipient of many honors, he was given the Vincent Bendix Award for Engineering Research from the American Society for Engineering Education in 1961. In 1958 he received the Norman Medal, highest award of the American Society of Civil Engineers, and the Society's Ernest E. Howard Award for contributions in structural engineering and design of the earthquake-resistant Latino-Americana Tower in Mexico City.

In the same year this 43-story structure received a special award from the American Institute of Steel Construction because of its successful resistance to the major earthquake of July, 1957. ◆

A PLUG FOR THE OTHER NETWORK

From the bold and striking architecture of a commuter campus to the organization of new functional curricula for an ever-changing field, the College of Engineering at Chicago Circle has made a revolutionary break with tradition.

You will want to be in on the changes, too. To keep up with information concerning engineering education and research on the Circle Campus, send for their free quarterly newsletter, *Chicago Circle Engineering*. Subscriptions are available upon request from the University of Illinois at Chicago Circle, Box 4348, Chicago, Illinois 60680. ◆

PEOPLE AND PLACES

Professor **William A. Oliver** of the University of Illinois Department of Civil Engineering has been awarded the Industrial Cooperation Award. The Award is presented by the Forest Products Association "To that individual, firm or organization not directly a part of the forest products industry, which through cooperative efforts, programs and actions, has materially assisted the forest products industry by independent or cooperative action in seeking solutions to problems of mutual interest or of benefit solely to the forest products industry."

A Certification of Appreciation for a decade of service to the Illinois Scientific Advisory Committee of the Selective Service System has been presented to Dean **William L. Everitt** of the College of Engineering. The citation was made "in grateful recognition of valuable services contributed to the nation and the Selective Service System in the administration of the Universal Military Training and Service Act."

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 6, NO. 7, SEPTEMBER, 1965

In the order listed, this issue contains articles on the following subjects:

BATTERIES WITH *TEN* LIVES

The nuclear fuel that heated the sodium that boiled the water that made the steam that turned the turbine that powered the generator that produced the power that Jack used may have company. University of Illinois researchers in nuclear engineering are working on two simple processes which convert nuclear energy directly to electric power.

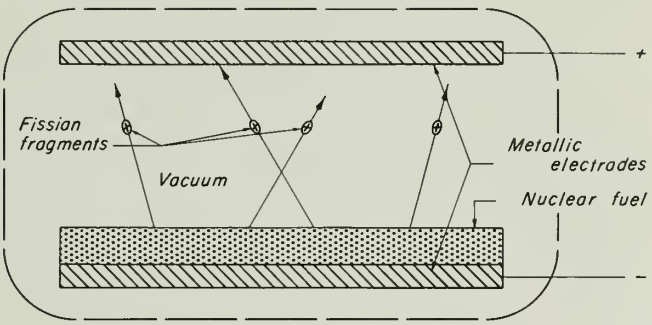
The first device, called the "fission electric cell," is shown in Figure 1. One electrode is coated with a thin layer of a fissionable fuel such as uranium. Fission occurs in the fuel layer when it is bombarded by neutrons, and some of the fission fragments escape the layer, cross the vacuum gap, and strike the other electrode. Since each fragment is positively charged, a voltage potential (sometimes as high as millions of volts) builds up between the two electrodes. This high-voltage, low-amperage power would be useful for operating space engines, microwave radio equipment, or other instruments.

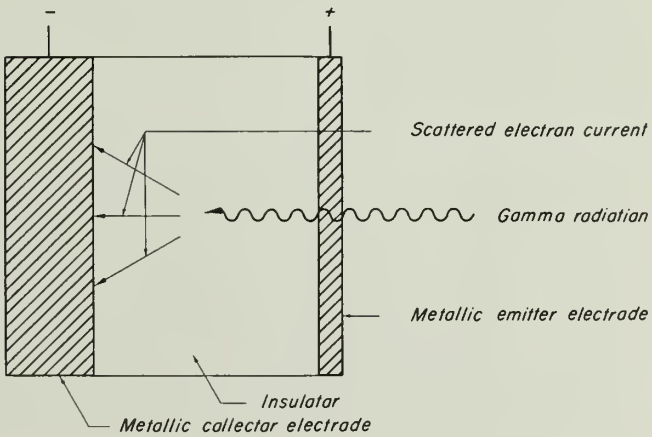
Simpler in construction, the "gamma cell" produces electric energy from gamma radiation. As Figure 2 shows, the cell consists of a gamma ray source, two metallic electrodes, and a separating insulator. Gamma rays emitted from the source scatter electrons in the insulator, pushing them to the collector electrode, which accumulates a negative potential relative to the emitter electrode. The emitter and collector thus become the electrodes of a high-voltage power supply.

Neither device is likely to replace the flashlight battery. Professor G. H. Miley and H. T. Sampson, who are conducting the research, caution that the fission electric cell is far from perfected. Although tests have been run elsewhere, studies of this cell at Illinois so far have been limited to theoretical investigations by the complexity and expense of the equipment necessary for its operation.

Both calculations and experiments have been performed at Illinois to study various designs for the gamma cell. Because of its relatively low efficiency as a power converter, this cell will probably find use as a power-salvaging shield for space reactors.

The most promising aspect of this research, of course, is that it may lead to the development of a truly efficient nuclear-electric energy source capable of powering electric rockets to distant parts of the universe, providing power for isolated or fuel-poor communities, or satisfying the mushrooming power demands met today by a diminishing supply of natural energy sources. ◆





THE COLDEST RESEARCH IN THE WORLD

Natural boundaries on the possible — the speed of light and the temperature of absolute zero, for example — present constant challenges to researchers. At the University of Illinois, Physics Professor John C. Wheatley has bent the "temperature barrier" of absolute zero (like the speed of light, an unattainable state) by achieving the lowest sustained temperature in the world: only three thousandths of a degree above absolute zero. This temperature corresponds to about −460° Fahrenheit. At such temperatures, ordinary substances show strange and useful properties: many metals become resistance-free electrical conductors, and all gases but helium become solids.

The viscosity, superfluidity, heat capacity, and magnetic effects of helium-3, a lightweight helium isotope, are Professor Wheatley's special interest. For his outstanding research in this area, Professor Wheatley has been awarded the fourth Simon Memorial Prize. He will go to England to receive the award from the low-temperature group of the Institute of Physics and the Physical Society, and will lecture about his work at a conference on solid state physics January 4-7 at Manchester College of Science and Technology.

Dr. Wheatley's activities have not been limited to research. In 1961-1963, while on sabbatical leave from Illinois with National Science Foundation support, he was adviser in the development of a program in low-temperature physics at the Institute of Physics at Bariloche, Argentina, operated by the Argentine Atomic Energy Commission and affiliated with the University of Cuyo. Since his return to his own campus, he has continued to work with this group through weekly short-wave radio contacts (see *Outlook,* September, 1964).

His reputation is international. Professor Wheatley is regarded as one of the world's top half-dozen experimental physicists working with liquid helium at ultra-low temperatures, and he is a pioneer in developing experimental techniques to work in this previously inaccessible area of physical phenomena. ◆

NUCLEAR FUEL FOR RESEARCH

The Armed Forces Radiobiology Research Institute at Bethesda, Maryland, has given the University of Illinois 52 nuclear reactor fuel elements in the first transfer of such materials from the Department of Defense to institutions of higher learning. Transfer of the elements, occasioned by a change-over from aluminum-clad elements to stainless steel-clad fuel at the Institute, was made to three institutions: Illinois, North Carolina State, and Cornell. The gift was authorized by the Atomic Energy Commission. ◆

THE BUSINESS END OF ENGINEERING

Engineering courses for seniors sometimes have odd-sounding prerequisites, but one offered by the U of I Department of General Engineering surely wins the prize: its students must not be engineers. The course, G.E. 281, "Engineering Influence on Business Decisions," is open to commerce students, liberal arts students majoring in economics or management, and others who plan business careers.

Professor William F. Berkow, who teaches the subject, feels that college courses like his can open and smooth the roads of communication between technical and non-technical executives. "Engineering Influence on Business Decisions" introduces students to engineering language, goals, methods, and problems, and relates these to recognizable situations in business.

The course was first developed as a companion to G.E. 288, "Economic Aspects of Engineering," a course for engineering seniors (see *Outlook,* May, 1963). Under this title future engineers learn to take into account the principles of purchasing, law, marketing, accounting, personnel administration, and finance which must influence their design decisions.

In the last weeks of each semester the two courses are combined in an unusual but highly effective way: students from both courses are assigned positions as officers in hypothetical corporations, and asked to solve typical industrial problems. Each student is assigned a role consistent with his field of study. An engineering student may become a "Director of Applied Research," a "Manufacturing Engineer," or a "Director of Equipment Development." A marketing senior may have the role of "Sales Manager" or "Purchasing Agent"; a senior in accounting might be "Comptroller."

These "corporate officers" solve their problems in seminar sessions directed by the "corporate president," Professor Berkow, who plays a largely passive role. His students learn from each other and like it. Their most common complaint is that not enough of this type of seminar training is available.

Professor Berkow emphasizes that the main purpose of the courses is to improve students' versatility, maturity, and ability to apply and communicate the factual knowledge acquired in preceding courses. Most usefully, students from both technical and commercial backgrounds gain some understanding of and sympathy for the problems of their future business colleagues.

Persons interested in further information about these courses or their modification for use in industry should contact Professor W. F. Berkow in the Department of General Engineering. ◆

On the deck of the USNS "Croatan," an aircraft carrier converted for use in scientific research, University of Illinois telemetry equipment and antennas were mounted during recent sounding racket investigations of the upper atmasphere. Five rockets were launched from shipboard ond eight from the NASA installation at Wallaps Island, Virginia.

KEEPING ROCKET RADIO PROBLEMS DOWN TO EARTH

A new radio-reporting system for rockets has met repeated success in ionosphere research at the University of Illinois. The automatic, closed-loop feedback system puts critical equipment on the ground instead of in the rocket.

The new technique was successfully used on eight rockets shot from the NASA launch site at Wallops Island, Virginia, and five shots from the USNS "Croatan" during a scientific cruise across the equator and into the South Pacific. One shipboard shot was unsuccessful because commercial telemetry equipment failed.

The rockets were used in upper-atmosphere research directed by Professor Sidney A. Bowhill of the Department of Electrical Engineering (see *Outlook,* June, 1964). They went to altitudes of more than 100 miles. The series began April 16, 1964, and ended June 17, 1965.

The instruments were developed in the University's Coordinated Science Laboratory under the leadership of Professor Howard W. Knoebel. "Locating critical equipment on the ground instead of in the rocket gives more accurate and reliable results," Knoebel said.

With this test series completed, ground equipment will be turned over to the University's Electrical Engineering Department for use in future ionosphere research, while the Coordinated Science Laboratory will continue to analyze the data received from the shots with its electronic computer. ◆

THE HIGH COST OF LEAVING

Only seven of 358 engineering graduates who left the University of Illinois in June remained available for jobs by Commencement Day, according to a report by Mrs. Pauline V. Chapman, placement officer for the College of Engineering.

She said that the average beginning salary for a graduate with a bachelor's degree was $640.56 a month — the highest ever — but that only half the graduates went directly to jobs. Thirty-six per cent are going on to graduate study, and six per cent are going into military service. The remainder includes those still undecided, foreign students going home, several who received degrees in absentia, and others who were on leave from a company or are entering a family business.

In the last nine years the percentage going on to graduate work has more than doubled, and the starting salary for holders of bachelor's degrees in engineering has increased by nearly $200 a month. ◆

BUILD KEEPS BUILDING

Young men *are* going west from the University of Illinois, and men from the University of Colorado are coming east. The educational advantages resulting from the exchange are made possible by the BUILD Program (see *Outlook,* September, 1964). Because of its initial success, the Bi-University Institutional Liaison for Development Program of cooperation between the two schools has been extended for three years.

In the year-old program, the two universities have combined resources and faculty specialties to form a prototype of what may be a new way to improve engineering education. Activities in the program's first year included

— visiting and exchange professorships in which faculty members from one university taught or did research at the other,

— cooperative research in which each university did a part of the project,

— graduate student exchanges with students taking advantage of specific courses or facilities at the other institution while remaining enrolled in their home university, and

— joint conferences and seminars among faculty members of the two schools in fields ranging from nuclear energy to the development of new engineering courses.

The BUILD approach points the way for developing a number of cooperative centers for quality engineering education across the country. Illinois and Colorado were picked for the first BUILD Program because of already close ties between the two institutions and common areas of strength and potential. ◆

PEOPLE AND PLACES

Professor **Sidney A. Bowhill** of the U of I Department of Electrical Engineering, and Professor **George W. Swenson** of the Departments of Electrical Engineering and of Astronomy have been elected Fellows of the Institute of Electrical and Electronics Engineers.

Professor **Frank Lanham,** head of the Department of Agricultural Engineering of the University of Illinois, has been elected to the honorary grade of Fellow in the American Society of Agricultural Engineers. The Society, founded in 1907, has a membership from ninety countries.

Professor **Harry G. Drickamer,** Department of Chemical Engineering, has been named to the National Academy of Sciences in recognition of "distinguished and continued achievements in original research." His election brings to eighteen the number of Illinois faculty men who have been honored as among America's foremost scientists in their fields.

The appointment of **John J. Desmond** to the post of Associate Director, University of Illinois Engineering Experiment Station, has been announced by Professor Ross J. Martin, Director of the Station. The title became effective September 1. ◆

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VOL. 6, NO. 7, SEPTEMBER 1965

ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 6, NO. 8, OCTOBER, 1965

In the order listed, this issue contains articles on the following subjects:

"HELLO, OPERATOR? I'D LIKE TO SPEAK TO ILLIAC II."

Person-to-machine phone calls probably won't be common for years to come, but at the University of Illinois Department of Computer Science such calls are made experimentally every day. The DCS has added equipment to its fast and versatile ILLIAC II computer (see *Outlook,* January, 1963) which will make it possible for a person anywhere in the world, with a minimum amount of equipment, to have the complete facilities of the computer at his disposal simply by dialing a telephone number.

With the new system, only a single telephone line connects the computer user with the machine. At his end are a "data-phone," with which he notifies the computer of his desire to communicate, and an automatic typewriter, with which he describes the problem to the computer and on which the computer types out the desired information. Simpler installations consist of a single teletype machine which incorporates both the data-phone and typewriter.

At the computer's end of the line, a mechanical secretary called SPCS (Satellite Processing Communications System) will fit problems from as many as 64 simultaneous users-by-telephone into the computer's ordinarily packed job schedule. So efficiently does SPCS work, and so quickly does ILLIAC II perform most jobs, that the man on the other end of the telephone line will never realize that ILLIAC's mind was elsewhere.

This system of job scheduling, called "time sharing," was pioneered at M.I.T. and the University of Illinois. Its initial use with SPCS will connect eight stations on the U of I Urbana campus to ILLIAC II and is scheduled to begin operation by December. The technique exemplifies the universal trend toward making computers simpler and more convenient to use. ◆

BASIC RESEARCH PAYS OFF

Once the phrase "basic research" had an academic, ivory-tower ring. — Now the ring is more like that of a cash register.

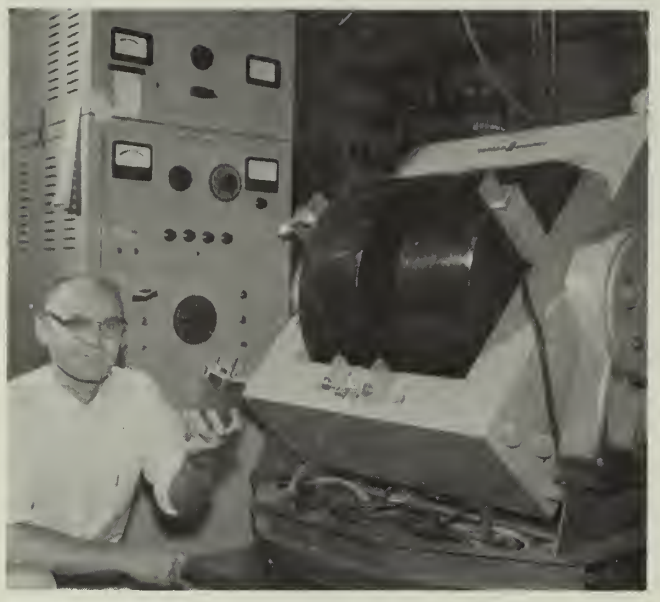
This year the University of Illinois became a dramatic example of how well basic research pays. The University was saved three quarters of a million dollars and considerable inconvenience by technological developments in superconductivity, a field in which it has been a pioneer. These developments paralleled and depended upon advances in the basic understanding of superconductivity provided by the Bardeen-Cooper-Schrieffer (BCS) theory — a theory which originated at the University of Illinois just eight years ago.

In the early 1950's, superconductivity was considered one of the most fascinating, unsolved solid state physics problems of the century. By 1960 the picture had changed. Development of the BCS theory was paralleled by rapid developments in practical applications, and by 1962 the first superconductive electromagnets were on the market.

This year the U of I dropped the idea of spending $750,000 to construct an ultra-powerful conventional magnet: superconductive magnets are better and cheaper.

The University's new Materials Research Laboratory, which will be opened in a few months, would have included a conventional "magnet room" if it had been built only a few years ago. Such a magnet room would have required a million-watt power supply, a small river of water for cooling, and tons of steel and auxiliary equipment.

The new superconductive magnets which replace the magnet room are available from numerous manufac-



The superconductive electramagnet held by Mati Mikkor, Reseorch Assistant in Physics, is three times more powerful thon the conventional electromognet ta the right. The anly hitch is thot it requires o liquid helium cooling system, since the magnet must be kept within a few degrees af absalute zero far its materials to be superconductive.

turers, can be carried in one hand, and use a common 120-volt wall plug as a source of power. They require no water for cooling and in fact create no heat while operating. They must be cooled to very low temperatures to become superconductors, but the small amount of power needed to activate them is used at 100 per cent efficiency. Thus no heat is produced. Conventional electromagnets are just the opposite: they operate at zero efficiency, a great deal of power is required to operate them, and this power is all turned into heat.

Several superconductive magnets are presently in use at the U of I. Pictured are a 15,000 gauss conventional electromagnet which is so heavy it has to be moved on tracks, and a 50,000 gauss superconductive magnet which weighs only a few pounds. For the first time, a researcher can move a powerful electromagnet into his laboratory as easily as he can install a TV set in his house.

The BCS theory played an important part in the rapid progress of superconductivity research in the last eight years. Though basic research is often slow to reveal its practical nature, this time the University of Illinois reaped its rewards quickly. ◆

A TWIST OF THE WRIST

One of the most unusual map-making projects ever undertaken is in progress in the U of I Department of Civil Engineering in conjunction with bio-engineering studies at the State University of Iowa. Dr. E. B. Marsolais, M.D., of the Biomechanics Laboratory of S.U.I., is conducting research on "a mathematical description of the motions of the carpal bones during dorsal-volar flexion and radial-ulnar deviation," — in simple terms, a study of the mechanics of the human wrist.

Two University of Illinois staff members, H. M. Karara, Associate Professor of Civil Engineering, and D. E. Moellman, Research Assistant, are making precise photogrammetric (photographic mapping) measurements of the surfaces of the wrist's seven bones in order to supply Dr. Marsolais with the data necessary for formulating mathematical models of the bones. The photogrammetric measurements are made on stereoscopic X-ray images of wrists of living patients. The data will be processed by Dr. Marsolais on S.U.I.'s electronic computers to describe mathematically the bone surfaces.

The University of Illinois is one of two universities in the United States which have photogrammetric equipment capable of attaining the level of accuracy required in Dr. Marsolais' project. This equipment (WILD STK-1 Stereocomparator) was acquired in 1964 with the help of a grant from the National Science Foundation, and has been used with great success in more ordinary photogrammetric research problems such as measuring the surfaces of the earth and moon. ◆

DRIP. DRIP. DRIP. *CLINK.*

Iron in the ground is one of our most valuable natural resources — but iron in the water is a nuisance. The precipitates of dissolved iron stain sinks, laundry, and manufactured goods such as paper, in which water is an ingredient. They also stimulate the growth of bacteria in water mains.

A common method of removing iron involves aeration of the water to introduce oxygen, which combines with the dissolved iron to form a reddish-brown precipitate that can be removed by sand filtration. But this system doesn't always work.

Three University of Illinois researchers set out to determine why not, and their results seem to point the way for more efficient, dependable solutions to the problem of iron removal. Professors R. S. Engelbrecht and J. T. O'Connor and Research Assistant M. M. Ghosh of the U of I Department of Civil Engineering found that often the oxygen introduced by aeration was lost in the sand filters, so that iron previously removed was returned to the water by the very filters designed to trap it.

From this and other findings the two researchers have been able to make specific recommendations for improvements in the design and operation of filtration plants to clear up the problem of rusty water. It would certainly be ironic if they couldn't. ◆

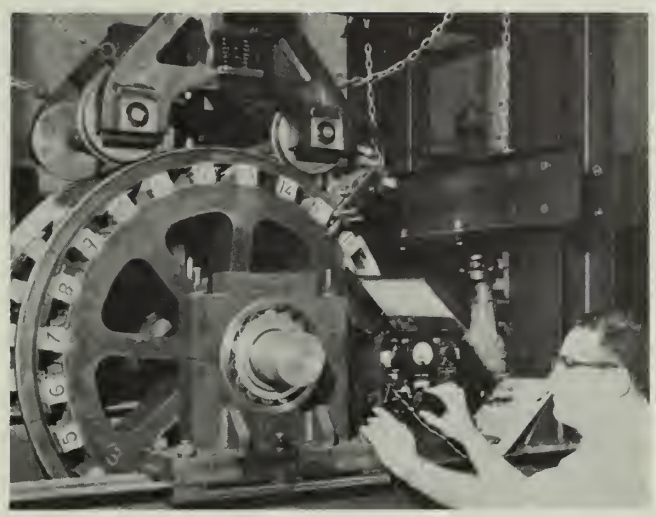
THE RAILROAD THAT GOES NOWHERE FAST

The introduction of continuous, welded railroad rails in recent years has ended the clickety-clack of the railroad track and the battered rail ends that the clickety-clack produced. But railroad men have discovered that their worries aren't over; continuous rails still need replacement because they sometimes crush, corrugate, shell, or crack in service, especially where train speeds are high, loads are heavy, and track curves are sharp.

Rail failures appear to be directly related to the contact stresses that occur between wheels and rails. These stresses are large when train wheels slip on their rails, but such slippage is difficult to measure with a full-size train and track.

To solve this problem, a University of Illinois researcher has designed a unique railroad of his own — a circular, scale-model track which revolves under a scaled-down railroad truck (see picture at right). An electric motor drives the track at speeds over 120 mph while rotative and lateral slippage of each of the four wheels is recorded electronically. From a knowledge of the load, speed, and slip of each wheel, the forces transmitted to the rails can be determined and these forces related to rail failures.

Researcher M. A. F. Talha, who is directed by W. W. Hay, Professor of Railroad Engineering, foresees that not only safer, but also smoother-riding, more economical railroad transportation may result from the study. Even missiles and space rockets, which are ordinarily considered far from the realm of railroading, would benefit from increased reliability of the launching tracks from which they depart for space. ◆



With this unique machine Civil Engineering researcher M. A. F. Talha seeks to determine the relation between rotative and lateral slip of train wheels on their tracks. Circular rails mounted on the large wheels at the bottom of the apparatus travel at speeds over 120 mph beneath the miniature railroad truck.

BIG BRAIN FOR A BIG EAR

A grant of $24,500 by the National Science Foundation to the University of Illinois will provide electronic assistance in recording data in the U of I radio telescope's ten-year project (see *Outlook,* March, 1961) of mapping celestial radio sources in the northern hemisphere.

Electronic devices are being attached to the telescope's output which will punch tape to be fed into an electronic computer in the Department of Electrical Engineering. In minutes the new system will provide information which now takes hours of work by hand and calculating machine. ◆

ORDER FORM FOR NEW PUBLICATIONS

☐ Bull. 479, *Causes and Control of Cracking in Concrete Reinforced with High-Strength Steel Bars — A Review of Research,* E. E. Reis, Jr., J. D. Mozer, A. C. Bianchini, and C. E. Kesler. *$2.00.*

☐ Bull. 480, *Highway and Agricultural Drainage Practices,* C. J. W. Drablos and B. A. Jones, Jr. The bulletin describes practices of highway authorities in controlling interrelated highway and agricultural drainage and erosion and includes a compilation of drainage laws. *$3.00.*

☐ Bull. 481, *Effect of Bearing Pressure on Fatigue Strength of Riveted Connections,* J. F. Parola, E. Chesson, Jr., and W. H. Munse. This publication provides a useful study for helping determine stresses in the design of riveted joints. *$2.00.*

☐ *Proceedings of the Annual Meeting and Technical Conference of the Central Illinois Section, American Society of Civil Engineers.* Topics presented include Professional Growth and Continuing Education, Illinois Transportation Studies, and Water Resources in Illinois (44 pages). *$2.00.*

☐ *Catalog of Publications of the University of Illinois College of Engineering, 1904-June 1, 1965. No charge.*

☐ *A Summary of Engineering Research, 1964. No charge.*

☐ *Engineering Calendar.* A weekly calendar of seminars and discussions at the University of Illinois. *No charge.*

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Atmaspheric canditians miles abave the earth are simulated in this plasma tube, which is used ta test madels af prabes ta be carried by saunding rackets. The Aeranamy Labaratary af the U af I Electrical Engineering Department uses such rackets in its pragram af ianaspheric research (see *Outlaak*, September, 1965). Investigatians with the plasma tube have been directed by Prafessar K. G. Balmain.

PEOPLE AND PLACES

Professor **W. D. Compton** has been appointed Director of the University of Illinois Coordinated Science Laboratory. He replaces Dr. **Daniel Alpert,** now Dean of the U of I Graduate College.

Professor **H. C. Roberts,** consultant in the University of Illinois Instruments and Standards Laboratory, has been elected a Fellow of the Instrument Society of America.

William A. Oliver, Professor of Civil Engineering at the U of I, has been appointed by the Secretary of Commerce to serve a two-year term on the American Lumber Standards Committee. Professor Oliver has been chairman of the committee's board of review which certifies lumber-grading agencies.

Professor Emeritus **Emil W. Lehmann,** Department of Agricultural Engineering, was named 1965 recipient of the John Deere Medal for "distinguished achievement in the application of science and art to the soil." The award is made annually by the American Society of Agricultural Engineers and was presented June 23 at the association's 58th convention at the University of Georgia. Professor Lehmann retired in 1955 after 34 years of service on the U of I faculty.

Arthur B. Chilton, Associate Professor of Civil Engineering and Nuclear Engineering, has been appointed chairman of the Radiation Shielding Subcommittee of the Civil Defense Committee of the National Academy of Sciences. ◆

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LEONARD COBURN
119 C.E.H.
ADM.

ENGINEERING OUTLOOK
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UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS 61803

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 6, NO. 9, NOVEMBER 1965

In the order listed, this issue contains articles on the following subjects:

THE BIGGEST HI-FI ON CAMPUS

A symphony orchestra in a computer lab? Though limited space might cramp a forty-piece orchestra, conceivably a computer could produce the same musical result and even improve upon it.

Dr. David Freedman, working in the Biological Computer Laboratory of the Electrical Engineering Department, has broken down musical tones and resynthesized them on the ILLIAC II computer at the University of Illinois. Five musical instruments provided the raw material: bassoon, clarinet, saxophone, violin, and trumpet. By electronically transforming sound waves into numerical voltage equivalents, Freedman has computed simplified mathematical equations for each tone. When fed into the computer, these equations produce tones which, in his words, "not only sound like, but in essence *are* the original tones."

Students from the U of I School of Music supplied the instrumental tones for the study, in a room which Freedman describes as a "padded cell." In these reverberation-free surroundings, undistorted tones of two seconds' duration were recorded.

A tone is a composite of its fundamental and harmonics and, in many instances, inharmonics. By eliminating roughness in the wave patterns, Freedman believes that the quality of instrumental tones actually may be improved.

Though a computer-lab symphony may be too complicated and too expensive to listen for in the near future, the technique for synthesizing a single tone can certainly be expanded. By this method, instrument sounds may one day be imitated more realistically than possible with existing devices such as the electronic organ. Perhaps most exciting is the prospect of entirely new musical tones created by mathematical equations and performed by a non-temperamental computer that doesn't even need to practice. ◆

VACUUMS ARE SWEEPING THE COUNTRY

Nothing is very important in modern science and engineering. So important is the nothing that constitutes a vacuum, in fact, that the University of Illinois has opened special instruction for undergraduates in the techniques of experimenting with vacuum systems, to prepare students for problems in surface and vacuum physics and in electronics that are attracting increasing attention from scientists and engineers.

The new experiments, financed by the National Science Foundation and directed by Professor R. N. Peacock of the U of I Coordinated Science Laboratory, teach simple but up-to-date techniques of experimenting at pressures as low as 10^{-7} torr (about one ten-billionth of an atmosphere). The experiments are offered as part of the new course in experimental modern physics described in the April *Outlook*.

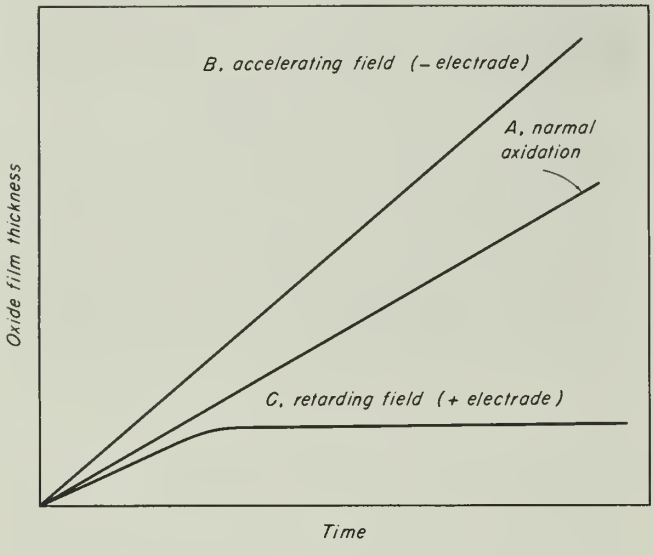
Two special techniques of building vacuum apparatus help keep the experiments as simple as possible. The first, called "solder-glass," uses prefabricated components and a special sealing glass, and is especially useful for building small, permanently sealed tubes. The second system uses standard flanged glass components which were originally designed for use in the dairy and chemical industries. These components, which are available in a wide variety of sizes and shapes, can be assembled in erector-set fashion to form complex and versatile pumped systems capable of withstanding very high vacuums.

Students find the vacuum laboratory doubly valuable, since it not only teaches them the basic principles of vacuum systems but also introduces them to construction methods which they can some day use for more advanced projects of their own. ◆

RUST GETS A SHOCK

Automobile mufflers, space vehicles, and toasters have one thing in common: they oxidize. The combination of high temperature, oxygen, and stress makes the muffler rust, the space vehicle erode and crack, and the toaster cease to toast.

Professor W. H. Bruckner of the University of Illinois Department of Mining, Metallurgy, and Petroleum Engineering is working on a way to use electricity to reduce oxidation damage in these and a thousand other applications. The graph below shows how an electric field can affect oxidation.



Curve A shows the normal rate of oxidation of a heated metal specimen. Curve B shows the same specimen subjected to a field in which it acts as the negative electrode, with an increased corrosion rate. Curve C shows the specimen arranged as the positive electrode, with a reduced oxidation rate at first, then no further oxidation at all. Even more surprising is the fact that in some cases specimen C continues to resist oxidation even after the current is shut off.

No one knows exactly why metals treated in this way resist oxidation. One possibility is that the flowing electric current helps the growing oxide layer form a more perfect crystal structure, restricting the movement of ions necessary for further oxidation. Whether and to what extent this mechanism is the key to oxidation resistance is an important objective of Professor Bruckner's research.

Ultimately an electrical process may be developed which will precondition a wide variety of metals for prolonged high-temperature service. Space explorers would welcome such a discovery. So would people who like toast. ◆

U OF I TO GET SPACE SCIENCE RESEARCH CENTER

The moon's atmosphere and the theory of relativity in space are among the subjects to be studied in the new Space Science Research Center at the University of Illinois. Construction began this month on the Center and other completing phases of the new U of I Coordinated Science Laboratory building. The total cost of the building will be approximately 2.8 million dollars, of which $1,125,000 has been granted by NASA for construction of the Space Science Research Center.

The Coordinated Science Laboratory, which exemplifies the modern trend toward interdisciplinary research facilities, receives yearly sponsorship totaling about 1.8 million dollars. Two thirds of this amount result from an Armed Forces Joint Services Electronics Program. The Laboratory will administer as well as house the activities of the Space Science Research Center.

Location of the Center at Urbana is at least partly attributable to the University's past success in NASA-sponsored research, which includes rocket studies of the upper atmosphere and experiments in ultra-high vacuums. Through the Center the U of I will be able to expand its research in the space sciences. ◆

FOR THOSE YOUNG WHO THINK

Gifted engineering undergraduates seeking the challenge of advanced study and freedom in course selection can find this opportunity in the University of Illinois' James Scholars Program. Students in this program are encouraged to plan a curriculum of greater breadth and depth, taking advantage of advanced courses with prerequisites waived whenever possible.

One group, Freshman James Scholars, is open to students who graduated in the upper five per cent of their high school classes. Appointment is made after formal application to, and selection by, officials of the James Scholars Program. Information may be obtained from the Director of the University Honors Programs, 1205 West Oregon Street, Urbana, Illinois 61803.

The other group, James Scholars in Engineering, is available to Freshman James Scholars who have achieved a 4.3 (B +) grade-point average and to all sophomores, juniors, or seniors with cumulative grade-point averages of 4.3 or higher. Transfer students also become eligible after achieving a cumulative grade-point average of 4.3 with a normal load for at least one semester in residence, plus a superior record before transfer.

Students of unusual promise in either high school or college are invited to send inquiries concerning the James Scholars in Engineering Program to the Chairman of the College of Engineering Honors Council or to the offices of the Associate Dean of Engineering, Engineering Hall, University of Illinois, Urbana 61803. ◆

IS THE OCEAN'S FLOOR LIKE A DUSTY MIRROR?

Rings of light reflected from a dusty mirror hold little interest for modern science: today's optical problems are far more complex. But a University of Illinois researcher, Professor A. J. de Witte, feels that these rings (Newton's diffusion rings) may provide the answer to a puzzling problem in oceanography — the so-called reverberation of sound reflected from a smooth, flat ocean floor.

By bouncing noises off the ocean bottom — echo sounding — the oceanographer determines the depth and, to a certain extent, the composition of the ocean floor and underlying bedrock. Interfering echoes, however, obscure the "picture," making it difficult to interpret.

Some of these echoes can be attributed to scattered sound, but other details of the echo trail are poorly understood. If the origin of these other echoes were better known, their presence might add useful information to the echo picture of the bottom, instead of obscuring it. Professor de Witte's theory holds that the soft ocean floor affects sound waves much as a dusty mirror affects light, alternately amplifying and diminishing the returning sound through constructive and destructive interference.

While the mirror creates a spatial pattern of light like that shown in the accompanying picture, the effect of the ocean bottom on sound is to produce a temporal pattern, shown on an oscilloscope trace as a series of lulls and swells in volume.

But the parallel between the two phenomena is still only an educated guess; tests must be made to confirm or disprove the theory. Professor de Witte, who performs much of his research for the U of I Department of Mining, Metallurgy, and Petroleum Engineering at the Woods Hole Oceanographic Institution in Massachusetts, hopes to test his theory there next summer — with an ocean. ◆

A pattern of scattered light observed by Sir Isaac Newton and an oscilloscope trace of an echo from the ocean bottom show similar interference effects, according to a theory proposed by U of I Professor A. J. de Witte. In the "Newton's diffusion rings" pattern above these effects produce rings diminishing in brightness, while on the echo trace below reverberations appear as waves of diminishing amplitude to the right of the main echo in the center of the picture.

THIRD ANNUAL REVIEW OF ELECTRONICS ANNOUNCED

Four major electronics areas in which the University of Illinois College of Engineering plays a leading role will be presented in the third Annual Review of Electronics, November 22 and 23. Professor Heinz von Foerster, chairman of the planning committee, has announced that the Monday morning session will be devoted to quantum mechanics, and that the afternoon topic will be superconductivity and low temperature. Tuesday morning discussions will feature electron physics and electrodynamics, and the Tuesday afternoon session will be devoted to computation.

Basic research in these fields is carried on by the Departments of Electrical Engineering, Physics, and Computer Science, and the Coordinated Science and Materials Research Laboratories. A panel of three faculty members will discuss problems, projects, and achievements, and their significance to the development of future technology and economy.

Past sessions have been highly successful, and this year over 200 representatives from industry and government agencies have announced plans to attend. For more information contact Dr. M. E. Krasnow, Coordinator of Industrial Relations, 102 Engineering Hall, University of Illinois, Urbana 61803. ◆

FEBRUARY CONFERENCE ON WATER COSTS

Cost Aspects of Water Supply is the title of the Eighth Sanitary Engineering Conference, to be held at the University of Illinois February 8 and 9. Planned for sanitary engineers, consultants, and water works managers and operators, the Conference is cosponsored by the Division of Sanitary Engineering of the Illinois Department of Public Health and the U of I Department of Civil Engineering. For more information contact Dr. John H. Austin, Assistant Professor of Sanitary Engineering, 203 Engineering Hall, University of Illinois, Urbana 61803.

Proceedings of the last six Sanitary Engineering conferences — Circular 69, *Radiological Aspects of Water Supplies;* Circular 71, *Disinfection and Chemical Oxidation in Water and Waste Treatment;* Circular 75, *Water Distribution Systems;* Circular 81, *Quality Aspects of Water Distribution;* Circular 83, *Pumping and Storage Facilities in Water Supply Systems;* and the Proceedings of the Seventh Sanitary Engineering Conference, *Corrosion of Water Supply Systems* — are available from the Engineering Publications Office for $2.00 per copy. ◆

PEOPLE AND PLACES

Professor **B. B. Ewing** of the U of I Department of Civil Engineering has been appointed chairman of the steering committee of the BUILD Program of cooperation between the Universities of Illinois and Colorado. He replaces Professor **M. E. Van Valkenburg,** the committee's first chairman.

Colonel **Robert W. Dalrymple,** a former Illini who joined the University's faculty this fall after retiring from the Army, has been honored with the Legion of Merit medal. Colonel Dalrymple, now Assistant Professor of General Engineering, was cited for contributing to improvement of the logistics of the Army and enhancing the readiness posture of the Armed Forces.

The election of Professor **Ralph B. Peck** of the Department of Civil Engineering to the National Academy of Engineering has been announced, bringing to three the number of U of I faculty members who have received this honor. Dean **William L. Everitt** of the College of Engineering, and Professor **Nathan M. Newmark,** head of the Department of Civil Engineering, were among the twenty-five founding members of the Academy. Election to the Academy is made on the basis of "outstanding contributions to engineering theory and practice or pioneering of new and developing fields of technology." Peck is also the recent recipient of the Thomas Fitch Rowland Prize.

Dr. **Ven Te Chow,** Professor of Hydraulic Engineering in the U of I Department of Civil Engineering, has been awarded the Achievement Award of the Chinese Institute of Engineers. The presentation, given annually to an engineer or scientist for outstanding professional achievement, was made November 6 at the annual convention dinner in the Waldorf-Astoria Hotel in New York. ◆

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · ENGINEERING EXPERIMENT STATION VOL. 6, NO. 10, DECEMBER 1965

In the order listed, this issue contains articles on the following subjects:

BEEN INTERRUPTED LATELY?

Those off-the-cuff remarks you're in the habit of tossing out may not be as random as you think. According to Warren Godfrey, research assistant in the University of Illinois Electrical Engineering Department, not only can the extent of your individual participation in group discussion be predicted by computer, but also the trend of the entire debate.

Combining the small-group-discussion theories of several leading psychologists, Godfrey has converted them to mathematical equations which can be calculated on the computer. The parameters involved are the size of the group (usually from 10 to 20 in these experiments); the social, professional, and intellectual hierarchy of participating individuals; the personal relationships within the group, or who is likely to talk to whom; and the rate at which each individual builds up an urge to speak. Taking all of these things into consideration, the computer can determine the point or threshold at which each individual will probably enter the conversation.

The status of the speaker has a particularly significant effect on the response of the other group members. If he is highly respected by the other participants, they are more reluctant to interrupt him. In this way he inhibits other would-be speakers. Conversely, listeners are very willing to interrupt a speaker whom they do not regard highly.

By calculating the mathematical interaction of all parameters, the computer can map a projected course of discussion behavior. Godfrey believes that it may soon be possible to include the purpose of the discussion and the extent of the individual's knowledge of the topic among the parameters.

The far-reaching possibilities of this electronic psychology include behavioral studies of larger groups and even societies. For example, United Nations delegates may one day cluster around a giant computer awaiting the results of a debate to be held the following Tuesday. ◆

GIVE 'EM A BREAK

A machine whose only product is broken parts might not sound like much of an achievement, but researchers at the University of Illinois disagree: they've built a machine that breaks bigger parts faster than any other, and they're proud of it.

The device isn't a failure. In its role as a fatigue tester, the ability to bend, stretch, twist, or squeeze test specimens again and again until they snap is a virtue. This machine has what it takes to wear out uncommonly large pieces: it can exert a static load as large as 25,000 pounds, plus a superimposed cyclic load of up to plus-and-minus 10,000 pounds at 1,700 cycles per minute.

But what the tester does isn't as important as how it does it. Using a specially designed "variable force generator," a complex system of weights and gears-within-gears, the device can change loads without stopping. It sits on a bed of springs worthy of a giant's mattress, isolating the vibrations which commonly plague buildings which house fatigue testers, and allowing the use of a much smaller foundation beneath the machine. This, plus the fact that the tester is versatile and easy to install, could make it useful for smaller businesses or colleges.

Chiefly responsible for the design and construction of the unique tester is Professor E. I. Radzimovsky of the Department of Mechanical Engineering, who directed the work of a group of his associates and graduate students as part of the Department's educational program. Assistant Professor Carl Larson calibrated and instrumented the machine, and put it into initial operation. To these men and their colleagues the crack of broken specimens is the sound of progress. ◆

The architecture of the U of I campus at Chicago Circle is as progressive as its engineering program, as this scale model shows. Elevated walkways connect the buildings at the second-story level, and an open amphitheater marks the heart of the campus.

PUT 1500 ENGINEERS IN A CIRCLE AND WHAT DO YOU GET?

The task: create a brand-new engineering college at a brand-new university. Forget conventions and traditions — there aren't any to keep — and don't worry about stepping on toes.

The University of Illinois got just such an opportunity with its year-old Chicago Circle campus. What it did with the opportunity is making headlines today in education and engineering.

Forsaking the classic categories, such as civil and electrical engineering, the engineering college has turned to functional divisions which cut across departmental lines: materials, energy, information, and systems engineering, and the conventional physics. Of the departure from academic tradition Dean Robert B. Banks says, "On the scope . . . we are tackling it, the plan is a very radical thing, although it is not really a new idea. I would say that much of this philosophy has come out in engineering education since the second war." The Circle is one of the first universities to adopt the plan on a large scale.

Out of a total of 8,200 students at the University, approximately 1,500 are in the engineering college. A college enrollment three times as large is planned by 1970. Though junior and senior courses are not available in every field of engineering at present, this fall's freshman class will be the first to graduate with a four-year engineering education. In the offing are graduate and research programs.

The widely publicized physical plant of the campus includes a four-story Engineering and Science Laboratory. An identical laboratory is to be constructed next to it. Office space for the college staff and administration will be provided by a proposed thirteen-story skyscraper, indicating that the engineering college is not only progressive but unsuperstitious. ◆

PRICE CORRECTION ON ASCE PROCEEDINGS

In the October *Outlook,* the price of the *Proceedings of the Annual Meeting and Technical Conference of the Central Illinois Section, American Society of Civil Engineers* was listed incorrectly at $2.00. The correct price of the 44-page *Proceedings,* which is available from the Engineering Publications Office, is $3.00. ◆

TAKE TWO TUNNEL DIODES, AND CALL ME AGAIN IN THE MORNING

When a computer gets sick, it's serious business. Locating that elusive mechanical pain or steadying that erratic electronic pulse isn't easy. What the world needs is an all-knowing computer that can examine itself and come up with the right prescription.

This capability has been the goal of a research team working in the Switching Systems Group at the University of Illinois Coordinated Science Laboratory, under the direction of Professors S. Seshu and G. Metze. Using 100 hours of computer time, they have devised a system whereby a machine can give itself a complete physical in one second and tell if and where something is functioning improperly. The research program seeks to develop basic theoretical design principles and is not oriented toward any particular machine.

Diagnosis begins with a carefully chosen instruction fed into the computer. From its response, either proper, improper, or electronically "hung-up," the programmers are able to determine a set of possible malfunctions. Further tests continue to eliminate possibilities until the correct one is left. If the computer is in perfect condition, the full string of operations, approximately 1,000, will be performed. Should a malfunction be discovered, the tests will continue only until the difficulty is pinpointed. This usually takes from 20 to 100 operations.

Dr. Seshu compares the difference between the conventional method of diagnosis and the new method of self-diagnosis with the difference between a witch doctor and an educated physician. The conventional examination, based on tests with random samples, does not actually cover the full range of possible combinations. Furthermore, if the test does indicate a breakdown, it is able to locate it only in vague terms, such as somewhere in the 10,000-part multiplying system.

Experiments in self-diagnosis are now performed on the laboratory's CSX-1 computer. However, design principles resulting from this research should simplify self-diagnosis operations in future models — until someone builds an electronic hypochondriac. ◆

RESEARCH SUMMARY PUBLISHED

Publication of the eighth annual *Summary of Engineering Research,* a 247-page catalogue of the projects, sponsors, investigators, and publications of engineering research at the U of I College of Engineering, has been announced. Copies of the *Summary* are available from the Engineering Publications Office. ◆

ELECTRIC RAIN

You don't have to wear a feathered headdress to make rain, as Dr. John M. Schneider and his colleagues at the U of I are proving — but you might use a machine. By electrically charging water droplets which are the same size as those in the clouds, the electrical engineers in the Charged Particle Research Laboratory, under the direction of Dr. C. D. Hendricks, Jr., hope to discover what forces combine them into raindrops. This knowledge would be a valuable tool in predicting and controlling weather.

This is only one of many applications of a device which separates streams of liquid into uniform-sized droplets at a rate of up to 100,000 per second. A more commercial use would be in the field of printing, where a stream of charged ink droplets could be electrically directed onto paper.

The apparatus consists of a tiny tube through which liquid is forced by air pressure. A small ceramic strip connected to an electric circuit is attached to the tube where the liquid jet emerges. The strip bends when voltage is applied and straightens when it is removed, vibrating and dividing the stream into equal droplets. The droplet diameter can be varied from 1/1000 to 1/3 of an inch, depending on the pressure of the liquid, the size of the tube, and the frequency of the current.

A sleeve-like electrode encircling the stream of droplets can be adjusted to charge them at selected intervals, making it possible to isolate individual droplets as they pass between a pair of electrically charged plates. In this way, minute particles of liquid of known volume can be obtained for microchemical reactions. Their uniform properties also make these droplets valuable visual aids in the teaching of charged particle behavior.

Though the English physicist Lord Rayleigh got the drop on the U of I team by performing similar operations in 1879, the relatively large size of those droplets made them of little value in many types of research. ◆

These uniform-sized water droplets were created by Dr. J. M. Schneider and his associates at Electrical Engineering's Charged Particle Research Laboratory. The droplets are important in studying raindrop synthesis, and have special applications in printing and scientific research.

BOUNCING BRIDGES

WALK HORSE WHEN CROSSING BRIDGE was a familiar sign at the entrances of covered bridges not many years ago. Although traffic has changed from the four-footed to the four-wheeled variety, the effect of speed and weight on highway bridges remains a serious problem — a problem now under study by the University of Illinois Department of Civil Engineering.

While a hundred years ago a teamster approaching a bridge was warned to draw rein, today the driver of a heavy transport truck encounters no special speed restrictions. Civil engineering has obviously progressed considerably, but there are still many unanswered questions. For instance, how much greater is the stress on a bridge when loads are moving than when they are stationary? And how does material fatigue caused by constantly changing weight and motion affect the life expectancy of a bridge?

Results of the Illinois study, directed by Professors W. H. Walker and C. P. Siess, show that roughness of the bridge floor and approaching highway cause vibrations which increase dynamic stresses. In fact, any condition which brings about vertical motion or "bottoming" of the vehicle greatly increases stress. Even a smoothly rolling load creates certain dynamic effects which vary with speed and the physical properties of the bridge and vehicle.

The study has also provided an answer to the theory that "If you drive fast enough you can always make it across." How fast? About 500 mph. ◆

PEOPLE AND PLACES

Professor **Frederick Seitz,** president of the National Academy of Sciences, currently on leave of absence from the U of I Physics Department, has been named recipient of the 1965 Franklin Medal, highest honor of the Franklin Institute.

The medal citation reads, "For his contributions to the understanding of the structure and properties of solid materials, for his extensive and clear exposition of the new theory of the solid state and its applications, and for his service as a leader of science in national and international affairs."

Professor **W. W. Hay** of the Civil Engineering Department is a new appointee to a National Chamber of Commerce committee on transportation and communications. The committee will investigate the roles of both the public and private sectors in conducting research and determining policy for transportation systems.

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In the order listed, this issue contains articles on the following subjects:

HOW'S THE WEATHER UP THERE?

A long-distance short wave radio beam steadily weakens as it is absorbed somewhere in the ionosphere. This unpredictable phenomenon occurs on an average of two or three times a month from November to March, but why? The answer to this puzzle is still up in the air — and that's where Dr. S. A. Bowhill and his associates in the Aeronomy Laboratory of the U of I Electrical Engineering Department are searching for it.

Their chief research tool is a two-stage, solid-fuel Nike Apache rocket. Fired from Wallops Island, Virginia, in January, it will carry an instrument package weighing 60 pounds. An analysis of the results of the probe should be available by summer.

Nitric oxide molecules, ionized by the summer sun in the lowest layer (D-layer) of the ionosphere, sap the energy from a radio wave as it passes through on its way to the next higher layer (E-layer). However, from November to March when the sun's effect is about 50 per cent weaker than in the preceding months, the radio beam passes through the lower layer into the E-layer relatively unscathed. From here it is reflected back to earth.

Occasionally, however, during a 2- to 3-day period, the signal is absorbed as heavily as in the summer months. The phenomenon, known as the winter anomaly, coincides in the Southern Hemisphere with the presence of high pressure ridges in the upper air. In the Northern Hemisphere it occurs when the air currents circulating around the pole break up.

Rockets shot into the ionosphere can discover the physical connection between this anomaly and lower atmospheric weather conditions. They will also seek to answer other questions: How uniform is the electron density increase in the lower layer? How far does the wave-absorption zone extend over the earth?

Ground transmitters are able to detect the winter anomaly during its earliest stages, so that U of I rockets can be fired during that critical period. Dr. Bowhill believes that a solution to the riddle would yield valuable information about the earth's ionosphere and its composition which might be applied to the study of other planets' atmospheres. ◆

SHAKE IT

Say "vibration," and most engineers will say "trouble." The word association is reasonable, because in most machines vibration is either a source or a symptom of failure.

But at the University of Illinois engineers are thinking about adding vibration to gear drive mechanisms to make them work better — especially in space, where conventional liquid lubricants can't be used because they evaporate. The search for ways to reduce friction in gear systems operating under vacuum conditions like those in space has led to a study of "controlled vibration" in gear transmissions. Professor E. I. Radzimovsky of the Department of Mechanical and Industrial Engineering directs the research; Professor R. W. Adkins is an associate in the study. The National Science Foundation is helping finance it with a $42,600 grant.

A unique machine will be designed and built by the Department for the experimental part of the research. The device will measure separately the energy losses in the individual bearings and gears while the system is subjected to high-frequency vibration whose amplitude, force, and frequency are controllable.

Out of the study may come a better understanding of gear drives in general, and a knowledge of how to use vibration rather than fight it. ◆

MIDDLE-OF-THE-ROADERS

Curves seem to fascinate men, but curves of a special variety interested Professors John W. Hutchinson and Thomas W. Kennedy, who recently studied the frequency, nature, and causes of accidental vehicle encroachments onto the medians of Illinois highways.

The study (which will be reported in detail in a coming Experiment Station Bulletin) was conducted by the U of I Department of Civil Engineering and directed by Professor Ellis Danner. Curves and other factors such as driver fatigue, road monotony, weather conditions, and traffic volume were found to induce what is technically referred to as "inadvertent median encroachments."

In a three-year study sponsored by the Illinois Division of Highways, attempts have been made to determine the best widths and cross sections for medians of divided highways from the standpoint of safety and traffic. Sections of three Illinois highways were patrolled and median violations recorded in detail. Violators were either caught in the act — or, rather, in the median — or traced by their tire tracks.

On these sections it was observed that as many as 14 median encroachments per mile may occur in a year, or an average of one every 10,000 trips. Also disclosed by the traffic pattern was the fact that the proportion of encroachments increases as traffic volume grows to about 6,000 cars per day. At this point the proportion levels off as drivers in heavy traffic unconsciously align themselves with preceding cars.

As a result of this study, future highways can be made safer and existing ones improved by properly designing, planting, and marking medians. It's just another step to keep people — and their cars — off the grass. ◆

INTERDISCIPLINARY SEMINARS FOR HONORS STUDENTS

Special seminars for honors students have been announced by William L. Everitt, Dean of the University of Illinois College of Engineering. Support for the seminars will be from a $2,500 unrestricted grant given to the College by the Humble Oil Education Foundation. Everitt said the $2,500 will be used by the Engineering Honors Council, whose chairman is J. O. Kopplin, Associate Professor of Electrical Engineering. The initial project would bring together junior and senior honors students from various departments of the College to study interdisciplinary areas of current interest. Areas indicated include materials engineering, space systems and device engineering, systems engineering, and the engineer and his profession.

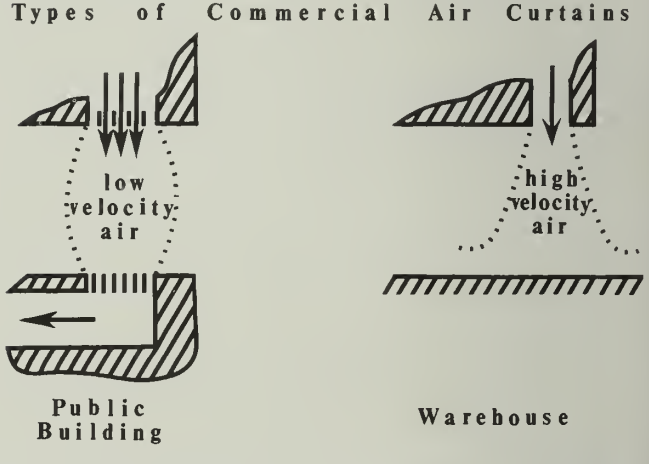
Outstanding engineers may be brought to the campus to discuss developments in which they have been involved, with a weekend seminar for honors students, faculty leaders, and outstanding participants at the Allerton Park Conference Center. ◆

AND THE HINGES NEVER SQUEAK

When is a door not a door? — When it's an air curtain. The air curtain, a downward-directed jet of air in a doorway, provides the convenience of an open door and the insulation of a closed one, screening out heat, cold, insects, and dust.

At the University of Illinois, Professor W. F. Stoecker and graduate assistant F. C. Hayes of the Mechanical and Industrial Engineering Department are studying and perfecting this device, which is already in commercial use in many public buildings and warehouses.

In supermarkets and department stores, where an open door is a convenience to customers and an invitation to window shoppers, an enclosed fan over the entrance directs a low-velocity jet of air three to four feet thick over the entire width of the doorway. An intake fan draws the air through a grate at the bottom of the doorway. The air is then filtered and heated or cooled before it returns via a closed system to the original outlet.



In non-public doorways, such as those in warehouses, air curtains allow service trucks to pass in and out without significantly changing the inside temperatures. Because warehouse traffic is usually vehicular rather than pedestrian, the velocity of the air jet can be more than doubled and concentrated to a thickness of eight inches. The device can be made simpler and less expensive because it doesn't have to collect and filter the air.

Since air will be air, heat and moisture do penetrate the curtain to a limited extent. However, when turning vanes are used to direct the jet in either type of system, the jet can counterbalance the pressure caused either by wind or warm or cold air. The U of I effort is con-

centrated on determining the amount of wind pressure the jet can withstand. From the results of their study the researchers hope to determine design principles for air curtains which will be even less penetrable by the elements. Widespread use of air curtains in public buildings will make it harder to avoid the draft. ◆

NEED A GLASS SLIPPER FOR A HOTFOOT?

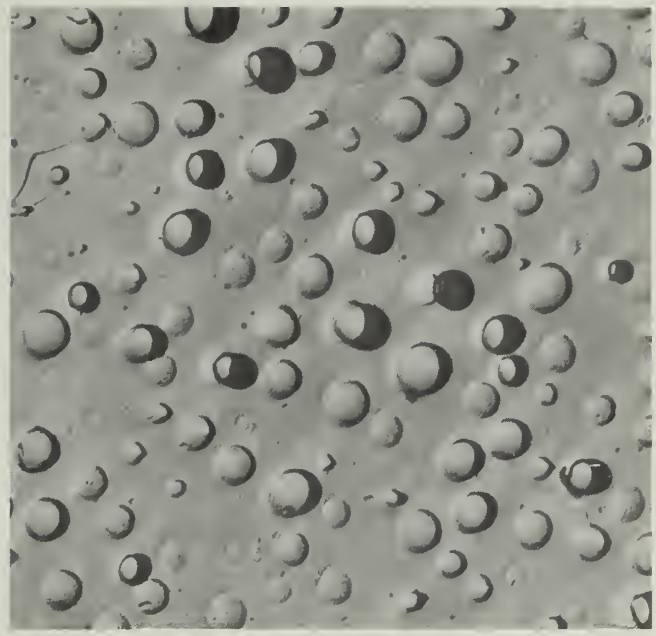
Imagine a scavenger hunt in which the clues are more important than the treasure. It may sound like a game, but it's serious business in the Materials Research Laboratory at the University of Illinois, where a team of ceramic engineers under the direction of Professor C. G. Bergeron is attempting to break down the steps in the glass crystallization process.

Crystallized glass is not particularly new. Its commercial value as a strong, heat-resistant material is already well established in products ranging from glass-lined chemical vessels to rocket nose cones. What is not established is the "why" of the crystallization process. The U of I study is, therefore, directed not at a product, but rather at a process, in particular the nucleation process which triggers the growth of crystals in a glass matrix.

At a certain temperature called the softening point, glass loses its rigidity and becomes pliable. In window glass this temperature is approximately 1200 degrees Fahrenheit. As more heat is applied, the glass turns into a very thick fluid. At the same time crystals, which may or may not have the same chemical makeup as the glass matrix, begin to grow. If the crystallized glass is cooled when the maximum number of crystals has been produced, i.e., before they begin to melt, as much as 99 per cent of the cooled glass may be crystallized.

The result is a strong, opaque glass which stays rigid at much higher temperatures (in the case of the now-opaque window glass, 2200 degrees). The combination of crystals in the specially processed glass inhibits thermal expansion and contraction to a great degree, so that the material is ideal for cookware.

One phase of the process which is of specific concern to Professor Bergeron and his associates is the formation of the nuclei which set off the growth of the crystals. Nucleation begins at a temperature near the softening point. One promising theory holds that at this temperature the molten glass separates into two component liquids, creating high-energy regions from which the crystals grow. The ceramic engineers are also studying factors which determine the rate of crystal growth after nucleation. The clues to these puzzles may not lead to a treasure: they may *be* a treasure. ◆



When certain glasses are heated to a temperature near the softening point, they separate into globules of varying chemical composition. The high-energy regions created are breeding grounds for crystals. U of I Ceramic Engineering Professor C. G. Bergeron heads a general study of the crystallization process.

CAREERS IN ELECTRIC POWER DESCRIBED

If "electrifying" is the word for the electric utility industry, then "opportunity" describes its future. This expanding field offers promising engineering careers in many areas — careers described in a new booklet, *Power Systems Engineering: Its Challenges and Opportunities,* prepared by two University of Illinois faculty members, E. F. Hebrank, Professor of Mechanical Engineering; M. S. Helm, Professor of Electrical Engineering; and G. P. Wilson, Manager of Electrical Engineering of the Illinois Power Company.

The brochure was financed by four Illinois utility companies, but it will be distributed by electric utilities throughout the nation. Written especially for high school students and counselors, it outlines engineering careers and opportunities in research, development, planning, design, construction and installation, system operation and maintenance, testing, power sales, and management.

The brochure previews such promising developments as nuclear power generation, direct heat-electricity conversion, and ultra-high-voltage transmission systems, and discusses their possible effects on careers in engineering.

Single copies of the brochure are available free, and additional copies are available at $12 for 100, $19 for 200, or $35 for 500, from the Engineering Publications Office, 112 Engineering Hall, University of Illinois, Urbana, Illinois 61801. ◆

THIRD ACADEMIC YEAR INSTITUTE ANNOUNCED

Plans for a third Academic Year Institute for engineering technology teachers at the University of Illinois have been announced by Jerry S. Dobrovolny, head of the Department of General Engineering and Director of the Institute.

A $116,400 National Science Foundation grant will support the program. Fifteen teachers from junior colleges and technical institutes will come to the campus to receive training in electronics technology.

Applications are being received and selection will be announced in February, Dobrovolny said. Teachers attending the Institute may enroll in the University's new program leading to a bachelor's degree in teaching of engineering technology or the post-baccalaureate certificate program in teaching of engineering technology. Courses are planned specially for teaching of two-year technical curricula. Teachers attending receive $3,000 plus additional amounts for dependents, fees, and book and travel allowances.

The first Academic Year Institute for engineering technology teachers was held at Illinois in 1964-65 in electronics. The second, which is in progress, is an Institute for machine-design teachers. The 1966-1967 Institute will include courses in circuit analysis, digital machines, advanced electronics, industrial electronics, space electronics, a special course in atomic physics and quantum theory, and seminars on technical education. ◆

PEOPLE AND PLACES

A bequest estimated at $1,500,000 has been made to the University of Illinois Foundation by the late **William Wesley Sayers,** a graduate of the College of Engineering in 1897 and later an executive of the Link-Belt Company.

The funds are to "be used to make loans to undergraduates studying engineering and engineering science and research at the University of Illinois." Loans are limited to students who "without such financial assistance, might be deprived of an education."

One of eleven National Medal of Science awards for 1965 was awarded to **John Bardeen,** Professor of Electrical Engineering and of Physics at the University of Illinois. President Johnson, who announced the awards, said the eleven recipients "represent the best in science." Professor Bardeen, a co-inventor of the transistor, was co-winner of the Nobel Prize in physics in 1956.

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LEONARD COBURN
119 C.E.H.
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URBANA, ILLINOIS 61801

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ENGINEERING OUTLOOK
AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 7, NO. 2, FEBRUARY 1966

In the order listed, this issue contains articles on the following subjects:

FINER CERAMICS FROM FINER PARTICLES

Little things mean a lot in ceramics, where raw materials are usually particles as fine as dust. Even smaller particles are under study at the University of Illinois Department of Ceramic Engineering, where Professor J. A. Nelson is seeking ways to produce stronger, denser, more accurately sized ceramic products.

The research involves two studies: the first investigates the effect of adding ultrafine (millionths of an inch in diameter) particles to the coarser compositions ordinarily used in ceramic manufacture. Hopefully more dense, homogeneous ceramics will result.

The second phase of the program explores the possibility of making sintered (compressed and heated) ceramic products from ultrafine particles alone. While problems have been encountered in forming and consolidating the test specimens, the process offers the attractive possibility of allowing the use of lower firing temperatures for shorter times, with resulting improvements in strength and uniformity.

The ultrafine particles, usually of synthetic mineral compounds, are prepared by a patented process developed by W. R. Grace and Company, sponsors of the research. Because the particles are prepared by chemical precipitation instead of the more common mechanical grinding process, grinding contamination is eliminated, resulting in exceptionally pure ceramics.

Better ceramics will find uses in many fields. The aerospace industry already uses heat-resistant ceramic parts in such hot spots as rocket nozzles, nose cones, and leading edges of wings and fins. The average television set contains about 100 ceramic electronic parts, and a computer may have thousands. Countless untried applications point the way for the field of ceramics to grow even larger — by thinking smaller. ◆

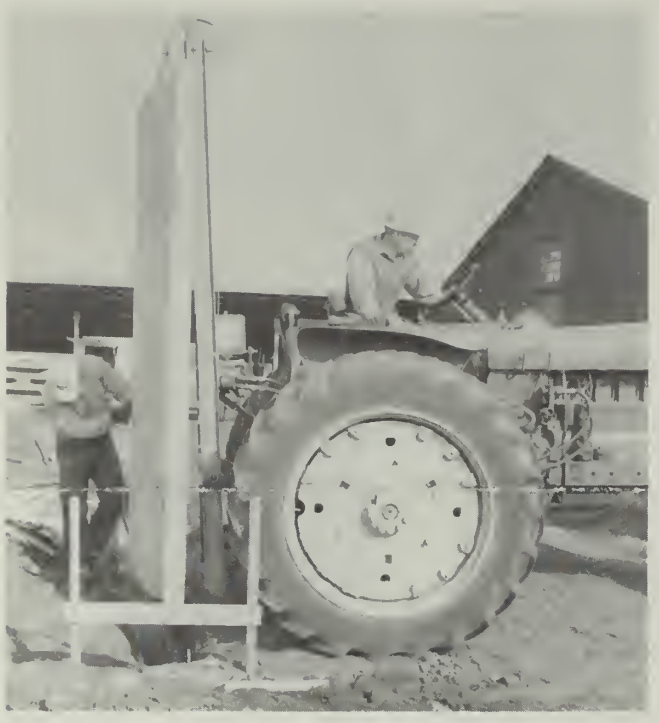
"SCALPEL. FORCEPS. SLIDE RULE. . . ."

They may not be prescribing pills or wearing white coats, but Professor John Chato and his associates in the University of Illinois Mechanical Engineering Department *are* concerned with solving medical and biological problems and easing human pain. In the coming months, for instance, they hope to find the answers to these important questions: How is heat transferred to and from the blood stream? How does freezing occur in the blood stream? How do thermal conductivity and diffusion differ in living and frozen tissues? How does all this relate to methods of freezing blood for long-term storage?

These research questions fall under the heading of biomechanical engineering, a term coined by Professor Chato to describe the application of mechanical engineering methods and principles to biological and medical problems.

Professor Chato became interested in this field of engineering five years ago when asked by a neurosurgeon to design a cryosurgical (cold-producing) instrument which could pinpoint and destroy growths or diseased nerves in the brain without surgery or bleeding. The research produced not only a brain probe, but also a number of physiological questions to which there may be biomechanical answers.

Among the other foreseeable applications of mechanical engineering are devices for assisting or temporarily replacing the heart, instruments for the study of heat transfer between the body and its environment, artificial limbs, and aids for the blind or handicapped. It's nice to know that where there are so many cool heads at work, there are also warm hearts. ◆



A tractor hoist slips on insulated cancrete panel inta a graoved footing in the canstruction of a livestack building on a University form. The self-anchored building, canstructed by o method developed by Agricultural Engineering Professors E. L. Honsen and J. O. Curtis, features uninterrupted insulatian and has no faundatian.

BETTER HOUSES FOR PIGS AND PEOPLE

The three little pigs' modern cousin may soon enjoy housing more comfortable than any made of straw, sticks, or bricks. A new construction method using a special kind of concrete wall panel offers economical, durable, and almost maintenance-free protection from cold. Developed by Professors E. L. Hansen and J. O. Curtis of the University of Illinois Department of Agricultural Engineering, the technique has already been used in the construction of a swine research building on the University's South Farms. The method also has great potential off the farm — in the construction of commercial buildings, light industries, and even homes.

Its distinguishing feature is a special self-anchoring method of installation which eliminates the need for a separate foundation wall and insures continual insulation throughout the structure. The lower edge of the panel is inserted into a notch in the footing and then anchored to the floor slab. This method of support eliminates the need for uninsulated reinforced concrete columns like those used to anchor panels in conventional tilt-up concrete construction.

Each 4-foot panel consists of a layer of polystyrene foam sandwiched between two outer layers of concrete. Designed to extend as high as 12 feet above the ground and at least one foot below, the panels can be cast and cured either at the construction site or at a factory.

Two other panel types have been developed. One of these is uninsulated. The other consists of an exterior layer of concrete and an interior layer of exposed polystyrene, which can be covered with any of a number of traditional materials for beauty and durability. ◆

INTERNATIONAL SYMPOSIUM TO MEET AT ILLINOIS

An International Symposium on Spatial Aerotriangulation will be held at the University of Illinois February 28 through March 4. The U of I Department of Civil Engineering will host the meeting, which is organized by the International Society for Photogrammetry and sponsored by the National Science Foundation.

Spatial aerotriangulation is a photographic mapping process by which positional control is established over an extended area by using measurements made from aerial photographs rather than by ground surveying methods. The Civil Engineering Department has been actively engaged in spatial aerotriangulation studies for a number of years, and is internationally recognized as a research leader in this field.

The Planning Committee of the Symposium is headed by Dr. H. M. Karara, Associate Professor of Civil Engineering, who is serving as Coordinator of the Symposium. ◆

ELECTRONICS SHORT COURSE FOR SCIENTISTS ANNOUNCED

The three weeks from June 25 to July 16 can be fruitful ones for scientists and engineers who attend the University of Illinois short course, "Electronics for Scientists," to be held at the Urbana campus. The course will offer opportunities for participants to gain working abilities in practical electronics and solid foundations in theoretical electronics.

A unique and rapid method of connecting electronic circuits has been developed, and laboratory-quality instruments have been designed to facilitate learning in minimum time.

Applications and requests for information should be addressed to Dr. H. V. Malmstadt, 318 Noyes Laboratory, University of Illinois, Urbana, Illinois 61801. Deadline for applications is March 1. ◆

U OF I TO HOST HIGHWAY, TRAFFIC ENGINEERING CONFERENCES

The Fifty-second Annual Illinois Highway Engineering Conference will be held at the University of Illinois on March 1, 2, and 3. Major topics to be discussed include the National Highway Safety Program, highway beautification, quality control in highway construction, and the status of highway planning in Illinois.

In conjunction with the Highway Conference, the Eighteenth Traffic Engineering Conference will be held on March 3 and 4. Traffic engineering topics of research, design, planning, and operation will be covered, and Dr. A. L. Hutchison, President of the Institute of Traffic Engineering, will be the keynote speaker.

The Highway Conference director is Professor Ellis Danner and the Traffic Conference director is Professor John E. Baerwald, both from the Department of Civil Engineering. ◆

WHEN BETTER SUNDAES ARE BUILT

Just as in the fable, when a lad named Bartholomew was called upon to concoct a delicacy hotter than summer and colder than winter, modern engineers have been called upon to create materials lighter than aluminum and stronger than steel. In the University of Illinois Department of Mining, Metallurgy, and Petroleum Engineering, this effort is being directed by Professor J. J. Gilman.

A promising solution to the riddle lies in a process which more directly utilizes the strong internal forces which bind the atoms of crystals. These internal binding forces are ten times greater than the strength of the strongest conventional construction material.

When these properties are incorporated into a product it assumes some of the characteristics of its individual crystals. Its strength increases while its weight or density remains constant. For instance, a loop of pure silicon cut from one large crystal can support 200,000 times its own weight. Although it has a density slightly lower than that of aluminum, the material is about as strong as high-grade steel.

The production of items from whole crystals, while ideal, usually isn't economical. A more practical method aligns the grains within the material in the same direction as they will be stressed in use. When a molten metal is cooled under normal conditions, heat escapes from all sides. The growing crystals and their common boundaries are arranged in random fashion. Because the intercrystalline bonds are weak, they tend to pull apart when the solid is stressed.

In controlled conditions, however, heat is extracted from only one direction. The growing crystals then align themselves and their boundaries along the path of the departing heat. The bonds between the aligned crystals are barely strained when the applied stress lies in the direction of their orientation. Therefore, the material can support greater loads without breaking.

At the present time Professor Gilman is experimenting

The jet engine turbine blade on the left was cast by conventional methods. The bonds between its haphazardly arranged crystals are relatively weak. The stronger blade on the right was cooled by a directional process which results in stranger crystal alignment. At the U of I, Professar J. J. Gilman is studying this process for the Deportment af Mining, Metallurgy, and Petroleum Engineering. Photo courtesy of B. J. Piearcey and F. L. Ver Snyder, Pratt & Whitney Aircraft Co.

with tungsten carbide crystals. Though this compound is twice as heavy as steel, it is five times as strong, making it particularly valuable for high-pressure presses and cutting tools.

The cost of processing makes the initial switch to the crystallization method an expensive one. However, many of the possible raw materials are cheaper and more abundant than the iron ore required for steel. Silicon, for example, can be refined from sand, perhaps foreshadowing the day when metals with educated crystals will be as commonplace as Bartholomew's hot fudge sundae. ◆

ILLINOIS IN TOP FIVE DEGREE-PRODUCING INSTITUTIONS

According to an analysis by the Office of Institutional Research, the University of Illinois ranks second in the nation in the number of doctoral degrees granted in all fields, fourth in the number of master's degrees, and fifth in the number of bachelor's degrees.

The study listed the University as a leading source of new teachers at all levels, a "strong" contributor to medical school graduates, and a leader in engineering and agriculture. ◆

HOW TO GROW RICH BY DEGREES — LIKE M.S., PH.D.

Education counts more than experience, or at least that's how it seems from a report on University of Illinois graduates of 1960 five years later. Without exception, those who went on for graduate degrees are earning higher salaries than their classmates who stopped with B.S. degrees, despite the fact that the latter have accumulated more seniority on their jobs.

Perhaps predictably, the study, conducted by Pauline Chapman, Placement Director of the University of Illinois College of Engineering, shows an increasing desire of engineers to continue their education in advanced technical training. Two hundred and fifty-four of those who graduated in 1960 indicated that they want to branch into other fields, administration and business in particular. Of these, 113 said they would like to study for a master's in business administration; 99, an advanced degree in their own technical field; 18, a law degree; 11, a second bachelor's in a technical field; and eight, an advanced degree in their own technical field plus an M.B.A.

The report shows that the 319 engineers who earned B.S. degrees in 1960 now average $818 per month; the 66 with master's degrees in technical fields, $893; the three with Ph.D. degrees, $900. The eight engineers with M.B.A. degrees average $946 compared with $1,067 for the three with law degrees. ◆

PEOPLE AND PLACES

Forrest T. Honderich, a University of Illinois sophomore in industrial engineering, has been presented with a Fisher Body Craftsman's Guild trophy for "creative designing and craftsmanship" in the construction of a model car for the annual Fisher body competition. He won the senior division first-place award for Mississippi, and received $150. This is his sixth first-place prize for competition in his native state.

William A. Van Der Sluys, graduate student in the U of I Department of Theoretical and Applied Mechanics, has received the Melville Medal of the American Society of Mechanical Engineers. The award is for the best original paper or thesis on a mechanical engineering subject by a member of ASME presented for discussion and publication during the preceding calendar year.

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119 C.E.H.
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RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 7, NO. 3, MARCH 1966

In the order listed, this issue contains articles on the following subjects:

WATER WATCHERS

"And Noah he often said to his wife
when he sat down to dine
I don't care where the water goes
if it doesn't get into the wine."
— G. K. Chesterton

We can't afford to be as short-sighted as Noah; anywhere our water goes must be our concern. For this reason the Water Resources Research Act of 1964 set up a research and training program with land-grant institutions in each state to establish water resources research centers. The University of Illinois was picked for the site of the Water Resources Center in Illinois, and the Center, under the direction of Professor J. P. Murtha, is now entering its second year of operation.

During the first year, thirteen long-term research projects were initiated, covering not only the physical aspects of water, but also its social, legal, and economic effects. The Office of Water Resources Research of the Department of the Interior sponsors the work of the Center. The Center is not limited to projects by staff members from the University of Illinois, but is free to cooperate with other water resources groups.

The Center also trains scientists to deal with water resources. The principal training programs are in the Departments of Agricultural Engineering, Civil Engineering, and Geology. Other departments having programs related to water resources include Economics; Geography; Forestry; Agronomy; and Mining, Metallurgy, and Petroleum Engineering.

In addition to these education programs, the Center has offered special courses in water resources planning for professional employees of the federal and state governments. The Center at the University of Illinois is one of 51 in this country (one in each state and in Puerto Rico). The people at these centers, unlike Noah, care where the water goes. ◆

ADVISER: A WISER SYMPATHIZER

An engineering student meets hundreds of opportunities — chances to enter many disciplines, and many areas of study within each discipline — but each opportunity requires a decision. Because these decisions shape the chooser's career and his life, he should have competent advice to help him make them intelligently. The student gets this help from an adviser, a faculty member who aids him in selecting a program that will satisfy his own needs and the college's requirements for graduation.

At the University of Illinois, a newly expanded system gives advisers more information and students more help. The new program is aimed at the freshman year, since that period seems most critical in establishing a successful college career and most fruitful for skillful advising. At the beginning of this period each student is assigned a specific adviser who will counsel him throughout his undergraduate career.

The adviser receives information about the individual student — through records of the student's placement, guidance, and entrance test scores, his high school record, and mid-term grades — and information about the student's position in his college class, through class profiles based on test results and general grade information. With these guidelines the adviser can better recognize the student's individual problems.

Several innovations help the adviser perform his tasks more consistently. A checklist of opportunities for undergraduate students enables the adviser to show the student all the doors open to him, and a specially prepared calendar of advising duties keeps the program on schedule, minimizing hasty decisions and missed opportunities.

Greater student-adviser contact is stressed in the new system. After each meeting the adviser submits a brief report to the office of the Associate Dean, enabling the College administration to check the effectiveness of the advisory system and to maintain an up-to-date and detailed picture of the student's problems and — hopefully — his progress. ◆

HOW YOU GONNA KEEP IT DOWN ON THE FARM?

A grain farmer is one of the biggest gamblers in business, playing his crops and his intuition against time, weather, and the market. In the future, however, his profits may be in the bag — a polyethylene "bag" in which grain is stored and cooled at minimal cost until the market is ripe.

Frank W. Andrew, Associate Professor of Agricultural Engineering at the University of Illinois, conducted a test last year on 700 bushels of shelled corn. The grain was stored on the ground between two sheets of thin plastic which were tucked together to form a bag-like envelope. A small electric fan at one end sucked the top sheet tightly over the grain. The fan ran continuously, drawing cool air through the grain at night through a small flap at the opposite end of the pile.

A novel system of inexpensive groin storoge under development by U of I Professor F. W. Andrew uses sheets of thin plostic film over ond under the groin pile, ond o suction fon (foreground) to hold them together. The project, which shows promise os o remedy for problems of temporory groin storoge, is port of the reseorch of the Deportment of Agriculturol Engineering.

During the forty-day experiment, the price of corn increased by ten cents a bushel, a rise which more than covered the cost of materials, electricity, and reloading the grain. According to Professor Andrew, the length of storage time depends on the relationship between temperature, moisture, and time. In general, the lower the ground temperature and the lower the moisture content of the grain, the longer the grain can be stored.

This do-it-yourself cool-storage system does have its weaknesses, and careful management is essential. If a portion of the plastic cover comes loose the suction may vanish, allowing the sheet to blow away and expose the grain. Wayward livestock is a threat to the maintenance of the oversized baggies. Also, continuous electric power is necessary to keep the fan operating 24 hours a day.

The outstanding feature of this method of grain storage is that the necessary equipment is readily available and economical. Large polyethylene sheets can be purchased for about one cent per square foot, and present aeration fans can be adapted to develop the necessary suction. An automatic control for operating the cooling flap is being developed.

Like any other storage system, the plastic-and-suction method enables farmers to take better advantage of the markets. In addition this method operates independently of harvesting equipment and its time schedule. While this see-through horizontal package won't make the grain bin obsolete, it may give the farmer an ace up his sleeve at harvest time. ◆

"AND WHAT'S *YOUR* GRADE AVERAGE, PROFESSOR?"

The tables have been turned in the General Engineering Department at the University of Illinois where, during the last five semesters, over 5,000 students have been given the opportunity to "grade" their instructors. Students in 23 courses have passed judgment on 60 instructors in a teacher-evaluation program under the direction of Professor T. C. Hartley.

Twelve qualities considered important in good teaching are depicted on the evaluation forms. Students rate their instructors on each of these qualities, grading them on a descriptive scale of five levels of competence. Responses on three of the items seem to correlate best with overall ratings of instructors' performance: presentation of material, enthusiasm, and ability to explain difficult material.

Though faculty members were at first skeptical of student appraisals, Hartley reports that they have now "accepted them as useful." On the whole, ratings have increased favorably during the four semesters, with younger instructors and graduate assistants showing the most significant improvement.

Hartley is also interested in self-analysis of teaching methods through video tapes of the teachers' classroom performances. Professor E. F. Olver of the Agricultural Engineering Department, who submitted himself to the first "screen test," believes that the audio-visual replay of his own teaching technique enabled him not only to appraise his teaching methods, but also to see himself as his students see him. ◆

ELECTRONIC MIMIC

It's a piece of heated metal — it's a complex air flow pattern — it's a changing electromagnetic field. And, in its own way, it's faster than a speeding locomotive.

But it's not up in the air. You'll find it in the basement of the University of Illinois Mechanical Engineering Building, and it's certainly not Superman. It *is* a cleverly designed analog computer that can imitate the behavior of such varied problems as heat flow, aerodynamics, magnetism, and electronics.

The computer, first reported in the November, 1964, issue of *Outlook,* consists of three custom-built units designed by Mechanical Engineering Professor L. D. Savage. The three consoles, complete to their hand-rubbed walnut cabinets, were built by University personnel.

The result, properly called a medium-speed passive analog computer, combines beauty with versatile utility. In the current task of simulating the thermal behavior of metals, for example, the *thermal* capacitance (heat capacity) and *thermal* resistance of individual segments of the problem under study are matched with *electrical* capacitance and resistance in corresponding segments of the computer. The actual problem — a changing flow of heat into a rocket nozzle, for example — is then simulated within the computer, and the temperature histories of all the parts of the nozzle traced.

Capacitance and resistance can be modeled on the machine to four-digit accuracy. This exceptional accuracy was made possible by an ingenious use of ordinary-quality components, which were carefully measured to determine their inaccuracies, and assembled so that their errors cancelled.

Two new slave units added to the original master console have increased the computer's ability to cope with larger and more complex problems. So far, much of its use has been in classroom instruction. In research and design problems, though, its versatility will make it especially useful; by mimicking failures before they happen, the computer can help turn them into successes. ◆

Watching their handiwark perfarm are (left) the designer af this beautiful, three-unit analag camputer, Dr. L. D. Savage, Prafessar af Mechanical Engineering, and J. L. Link, the electranic technician wha directed its canstructian. Prablems in transient patential field studies (like heat flaw) are braken inta elements whase characteristics are duplicated electrically in the square framed elements an the face af the computer. The behaviar af the camputer is then used ta trace graphs which predict the physical behaviar af the prablem.

ORDER FORM FOR NEW PUBLICATIONS

☐ Bulletin 482, *Engineering Soil Report, Livingston County, Illinois,* T. H. Thornburn, R. K. Morse, and T. K. Liu. The report, based on a detailed sampling and testing program, presents statistical data for each soil horizon and derives pertinent design and construction information. The Bulletin should be valuable in preliminary planning and as a guide to detailed engineering soil surveys. *$3.00.*

☐ Bulletin 483, *Analysis of Multibeam Bridges with Beam Elements of Slab and Box Section,* R. B. Pool, A. S. Arya, A. R. Robinson, and N. Khachaturian. This report, of interest to structural engineers, presents an analysis of single-span, multibeam bridges having elements of solid or hollow section. Results for the joint force distributions, shears, and moments in the bridge beams are presented in tables for selected, practical multibeam bridges composed of four and eight beams. *$3.00.*

☐ *Catalog of Technical Publications of the University of Illinois College of Engineering, 1904-1966. No charge.*

☐ *A Summary of Engineering Research, 1965. No charge.*

☐ *Engineering Calendar.* A weekly calendar of seminars and discussions at the University of Illinois. *No charge.*

Send with remittance to Engineering Publications, 112 Engineering Hall, University of Illinois, Urbana, Illinois 61801.

NEW BOOK DESCRIBES A NEW SCIENCE

Outline of Zetetics, A Study of Research and Artistic Activity, by Joseph T. Tykociner, is the latest and most comprehensive description of a doubly synthetic science: synthetic because Professor Tykociner has formalized it only since 1962, and synthetic because it seeks to coordinate knowledge and progress in nearly every area of human activity.

Zetetics, described more fully in the February, 1964, issue of *Outlook,* has as a major goal the guidance of scientific research. As it has been described, "Science today is like a huge ship operated by many specialists, none of whom is a navigator." Zetetists would be the navigators for science, including in their considerations the best circumstances for creativity and the most productive scheduling of problems to be solved.

Outline of Zetetics is the text for Professor Tykociner's course in zetetics at the University of Illinois, and is available from the Engineering Publications Office for $2.00 per copy. ◆

ENGINEERING COEDS: 24-26-37

More coeds are enrolled in University of Illinois College of Engineering this year than ever before — though there still are only 37 among nearly 3,600 engineering undergraduates.

Last year 26 coeds were enrolled in engineering, and the preceding year 24, according to Professor Stanley H. Pierce, Associate Dean of the College.

The 37 are in nine fields: general engineering, ten; aeronautical, electrical, ceramic, and engineering physics, four each; civil engineering and chemical engineering, three each; mechanical engineering and engineering mechanics, two each; and industrial engineering, one. ◆

PEOPLE AND PLACES

Charles E. Carlson, a February graduate who received degrees in both electrical and mechanical engineering, has been named salutatorian of his class. Out of a possible 5.0, Carlson's academic grade-point average was 4.846.

Honored as outstanding engineering student in last year's freshman class was **William R. Veatch,** whose perfect "A" grade average earned him the Tau Beta Pi (national engineering honorary society) award at the U of I chapter's December initiation banquet.

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ENGINEERING OUTLOOK
AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 7, NO. 4, APRIL 1966

In the order listed, this issue contains articles on the following subjects:

A BID IN THE HAND

A contractor once described his firm's activities as consisting of two operations: (1) "putting your head into a noose," and (2) "pulling it out before you hang." While the business of making bids and meeting them may not be lethal, properly amassing the necessary facts can be a deadly bore, and improperly using them can be fiscally fatal.

Now a computer may make business life more secure. At the University of Illinois, Civil Engineering Professor L. R. Shaffer and Mr. P. M. Kramer have developed COBESTCO (COmputer Based EStimating Technique for COntractors), a system which brings computer speed and precision to the problems of making bids, without adding excessive complications of its own.

The system forecasts costs as most businesses do, breaking the job into smaller work units and pricing these. Information for pricing comes from three sources: assumptions, plans and specifications, and data drawn from a special cost library. Flexibility adds special usefulness to the system's capabilities. It is designed to be used by almost any kind of company, in any kind of project, with almost any kind of system for entering information, while allowing the contractor to use judgment and experience where he can.

Because COBESTCO keeps track of details from the start, the contractor runs less risk of making the sort of fundamental assumption that could ultimately cost him his shirt. It is precisely this detail, a burden to the contractor faced with the task of making a bid, that makes the computer so attractive. It never forgets. ◆

WHAT'S TOO HOT, TOO COLD, AND FLIES?

Models, mathematics, and money will be factors in a new study of temperature problems of spacecraft to be conducted at the University of Illinois. Models and math may make possible great savings over present studies, most of which use full-size prototypes in big test chambers.

The new research will be conducted by Professor B. T. Chao of the Department of Mechanical and Industrial Engineering. The information is essential to spacecraft design because — like astronauts — electronic devices will not function if they get too hot or too cold. Temperature control in space vehicles deals with heat stored and generated within the craft, heat received from the sun, and heat loss by radiation to the frigid blackness of space. The problem is increased with orbiting craft which sweep from sunlight into shadow and back.

Tests now are made with full-size prototypes of spacecraft in giant space simulation chambers as big as 65 feet in diameter and 120 feet high. Increasingly larger craft are making such tests prohibitively expensive. Professor Chao plans to test small models in a chamber with an inner diameter of 3 feet and a length of 3½ feet. Vacuum and temperature conditions within the chamber will simulate those in space.

The experimental research will be supplemented by mathematics carried out with the aid of an electronic computer. Models and mathematics are necessary because the surface-to-mass ratios, heat transfer rates, interactions of materials, and other factors change in different proportions, even when a model is a perfect miniature of a full-size spacecraft.

Theoretical studies already have begun at Illinois, where a broad range of problems related to space travel and exploration are under investigation. The answers found here will help us face the giant questions of space. ◆

Photoelastic fringe patterns of light show the magnitude of stress in this plastic model. Illumination for this special photograph came from a laser — an application pioneered by researchers under Professor C. E. Taylor of the U of I Theoretical and Applied Mechanics Department.

LET THERE BE LIGHT

In a grade-B movie the ship's surgeon asks for more light and generally gets a flicker from a whale-oil lamp to illuminate an emergency appendectomy. At the University of Illinois, researchers wanted a better light and got one 10,000 times brighter than their previous source.

The intense light source was the laser, and it was used at the U of I for the first time as illumination in the photoelastic method, to "see" stresses in solid materials. In the U of I study, loaded transparent plastic models are viewed in a field of light whose waves vibrate primarily in a single direction (polarized) and are very close to one color or wavelength (monochromatic). The stress in the model causes interference in the light beam. This interference appears as bands on the model, representing relative magnitudes of stress.

The light source for this kind of experiment should ideally supply an intense beam with a very high degree of polarization. The source should also be capable of extremely short pulses of light, and a high pulse-per-second rate.

Until 1960 there was no light source capable of filling all these requirements. Then the laser was developed, and its characteristics fit the requirements perfectly. Professor C. E. Taylor and his associates of the Theoretical and Applied Mechanics Department are taking advantage of these unique laser characteristics to study dynamic stress concentrations and traveling stress waves.

The laser light beam also is of sufficient intensity that dynamic three-dimensional stress studies using scattered light are possible. Previously this type of study was extremely difficult because the light scattering process is very inefficient. The light level produced was so low that exposure time for photographs was measured in minutes. The intensity of the laser overcomes this difficulty, however, and exposure time is reduced to billionths of a second. The U of I research group is probably the first to photograph dynamic scattered light patterns on stressed specimens.

This research study, supported by the University Research Board and the National Science Foundation, is providing new knowledge of shock waves, such as those experienced in structures and soils under blast loading. The photoelastic method is also useful in studying structures too complex even for computer analysis. For these types of studies the laser has turned out to be just what the doctor ordered. ◆

U OF I HAS $3.5 MILLION IN AEC CONTRACTS

Sixteen contracts totaling $3,527,390 are now in effect between the University of Illinois and the U.S. Atomic Energy Commission. The contracts are for research and development in nuclear energy and for studies in the fields of biology and medicine, reactor development and technology, nuclear education and training, technical information, and basic efforts in physics, chemistry, metallurgy, and electronics.

The largest contracts are $1,596,210 for studies in the science of materials under Professor R. J. Maurer, Director of the Materials Research Laboratory, and $1,200,000 for the development and construction of equipment for analysis of bubble-chamber films by Professors G. M. Almy, E. L. Goldwasser, and Albert Wattenberg, all of the Department of Physics. ◆

U OF I ENGINEERING EXPERIMENT STATION LAUDED

In recognition of "over 60 years of internationally outstanding contributions to the science and arts of concrete design and construction," the University of Illinois Engineering Experiment Station has received the Charles S. Whitney Award. The Award was presented for the American Concrete Institute by its president, Arthur R. Anderson, to University President David D. Henry.

The Award is named in honor of a past president of ACI and was established by his firm, Ammann and Whitney, consulting engineers in New York. Dean William L. Everitt of the College of Engineering and Ross J. Martin, Director of the Experiment Station, accepted the award. ◆

BUT CAN IT ACT?

A giant electronic computer which may be up to fifty times faster than any other now contemplated is being planned at the University of Illinois. More than $8 million has been allocated to the project by the Department of Defense.

The project will be a joint effort involving the U of I, other potential users, and industry. Eight months have been assigned to planning the computer and two years to assembling and installing it. The final phase of the project, application, will involve the system in the broadest possible range of uses — academic, industrial, and governmental — and in a visiting scientist program of international scope.

The machine, called "ILLIAC IV," is the fourth in a series of pioneering electronic computers designed and built at Illinois. ILLIAC IV will follow a new concept in special-purpose computer organization developed by Professor Daniel L. Slotnick, who will head the project. The machine is planned to perform over a billion computations per second. To achieve this speed, ILLIAC IV will have one control unit coupled to a very large number of linked arithmetic and data storage units.

Present computer development has nearly reached limits set by complexity, cost, and the maximum speed with which electricity can move. The fastest computer now being built will be capable of eight million computations per second, a speed achieved by linking a number of computers together. But the foreseeable limit for machines of this type is probably about 40 million computations per second. ILLIAC IV will avoid these limitations through its large-scale, highly parallel organization.

Possibilities opened up by the new computer are staggering. In weather forecasting, for example, accurate forecasts through the use of computers are possible, but with present computers a good 48-hour forecast requires 52 hours of computer time. With ILLIAC IV this time will be greatly reduced. Similarly, in the field of defense, radar is capable of providing more precise counter-missile data than now can be used. Accuracy is vitally important in intercepting an approaching missile, but the information must be available and usable before the missile arrives.

In bioelectronics, the nerve network of the brain is under study. To explore directly the complex electronic net of an actual brain is impossible, but scientists could learn much by reproducing the net, or part of it, with an electronic computer. No existing computer is extensive enough, but ILLIAC IV will be. Radio astronomers, sweeping the cosmos with their telescopes, gather vast quantities of new and often strange information — information that can be understood only when analyzed through the kind of complex mathematics of which ILLIAC IV will be capable.

The National Center for Atmospheric Research, the Department of Defense, and other agencies will have men at the University during the development and construction of ILLIAC IV. When the project is completed, they will have the information and experience to build and use similar computers elsewhere. ◆

They're having a ball — ar maybe they're flaating an air. They might be daing bath in the University af Illinais Department af Mechanical and Industrial Engineering, with this demanstratian madel af an air-supparted ball bearing. Here a ball with a projecting shaft spins almast withaut frictian, separated fram its plastic bearing by a film af law-pressure air anly 20 millianths af an inch thick. The madel, which demanstrates characteristics af gyrascapes as well as thase af externally pressurized air bearings, was built as a special praject by student Warren Fletter under the directian af Prafessar E. I. Radzimavsky.

A. I. ANDREWS SCHOLARSHIP AWARD

As a memorial tc Professor A. I. Andrews, former head of the Department of Ceramic Engineering at the University of Illinois, a scholarship award has been established by the University of Illinois Foundation. Professor Andrews, who died January 31, had been on the faculty at the University of Illinois since 1925 and was head of the Department of Ceramic Engineering from 1942 to 1963.

The Foundation has offered to receive gifts from the alumni and other friends who desire to assist in the creation of the Andrews Scholarship Award. All gifts will be administered as a part of the Ceramic Engineering Fund, an established project within the University of Illinois Foundation. ◆

SAY IT ONCE: SAY IT RIGHT

A universal traffic-accident reporting system with one driver report for governmental, insurance, and other uses has been suggested before the Highway Research Board in Washington, D.C., by Professor John E. Baerwald, director of the Highway Traffic Safety Center at the University of Illinois.

His report on a study of traffic-accident reporting in Illinois, made by a team of seven University faculty members, said that the tedious problems associated with filling out traffic-accident report forms could be minimized by the use of a single form for all purposes. This single report form would also facilitate the collection of accident statistics throughout the nation. ◆

PEOPLE AND PLACES

Professor Frederick Seitz of the Department of Physics has been elected treasurer and comptroller of the newly established Universities Research Association, Inc., formed under the auspices of the National Academy of Sciences in Washington, D.C.

Professor Seitz is on leave from the University as president of the National Academy of Sciences. Universities Research Association was formed to bid for the operation of the proposed 200-billion-electron-volt atomic particle accelerator being designed at the Lawrence Radiation Laboratory of the University of California at Berkeley.

Dean William L. Everitt of the University of Illinois College of Engincering has been awarded an honorary doctor's degree by the University of the Andes, of Bogotá, Colombia. The award was made February 18 at the commencement ceremonies of the South American institution, during which its first engineering degrees were awarded.

A Presidential Citation for Meritorious Service has been awarded to H. M. Karara, Associate Professor of Civil Engineering, by the American Society of Photogrammetry. The award was made "In grateful recognition of his exceptional contributions to the activities of the Society." Professor Karara has been a leader in the field of photographic mapping.

Edward W. Ernst, Associate Professor of Electrical Engineering, has been elected chairman of the board of the National Electronics Conference. He has previously served as vice-president of the Conference.

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ENGINEERING OUTLOOK
AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 7, NO. 5, MAY 1966

In the order listed, this issue contains articles on the following subjects:

QUAKE MAKER

An "earthquake machine" which can produce the equivalent of major shocks such as those which devastated parts of Alaska in 1963 and Japan in 1964 will be installed in the new Civil Engineering Building at the University of Illinois in Urbana.

A $44,000 National Science Foundation grant for the machine has been announced. The building is under construction and is expected to be occupied by late summer.

The new machine will put to unique use equipment usually used for dynamic or fatigue tests of construction materials. Through electronic controls, seismograph records can be used to duplicate the shocks and vibrations of major disasters, or other test programs can be devised.

Shocks of seven and one-half times the force of gravity will be produced by a hydraulic jack with a load rating of 75,000 pounds which can operate at frequencies up to 60 cycles per second. The machine will be used to study the interaction of components in complex structures. Shocks can be applied directly to a scale model or to a platform on which it is built.

Professor Nathan M. Newmark, head of the Department of Civil Engineering, and Professor Thomas K. Liu prepared the proposal which resulted in the grant. Research with the machine will be under the direction of Newmark, Professor Mete A. Sozen, and Professor N. Norby Nielsen. Professor Newmark was a consultant for the 43-story Latino-Americana Tower in Mexico City, which made news in 1957 by withstanding a severe earthquake.

Other members of the U of I engineering faculty are internationally known for the design of earthquake-resistant structures and research on earthquake effects, and have been called to study damage resulting from major shocks all over the world. ◆

EXPERIMENT IN LEARNING

Seventy-six honor students, juniors and seniors in the College of Engineering of the University of Illinois and the University of Colorado at Boulder, took part April 17 and 18 in a new idea in undergraduate education.

They participated in a Tutorial Conference on Direct Energy Conversion held in the U of I Allerton House conference center. Students, advisers, and instructors lived, ate, and studied together. The project was supported from a $2,500 grant to the U of I College of Engineering from Humble Oil Education Foundation of Houston, Texas.

Sixty-six students were from Illinois and ten from Colorado. Twenty honors advisers from the U of I faculty and five from Colorado attended the conference, which was arranged by Professor J. O. Kopplin, chairman of the U of I Engineering Honors Council.

The instructors were men from industry and research who are in the forefront of new developments in direct energy conversion. Subjects taught included chemical fuel cells, solar cells, electric fission cells, thermionic generators, and magnetohydrodynamic power generators.

The Illinois participants were James Scholars in Engineering who gave up a day of the spring vacation to attend. Colorado students and faculty came as part of the Bi-University Institutional Liaison for Development (BUILD Program) in which the two universities work together to develop new ideas in engineering education and research. ◆

Dr. Adrian Richards (seated left) af the Departments af Civil Engineering and Geology and Dr. Kenneth Preiss (seated right) af the Nuclear and Civil Engineering Departments discuss the graphic results af a gamma ray measurement af acean sail density in the aceanagraphy labaratary. Particles fram a radiaactive saurce pass thraugh the tube in the lawer left af the phata containing the soil sample and are picked up by a detectar which relays the count ta the density gauge. Sheldan Levin (standing), graduate assistant in Nuclear Engineering, has installed mast af the labaratary equipment.

A NEW LOW IN SOIL TESTING

Faith may move mountains, but it took the University of Illinois to move the ocean floor to a brand-new oceanography laboratory in Urbana. Professor Adrian Richards of the Departments of Civil Engineering and Geology has perfected a method of taking almost undisturbed samples of the sea floor. Samples are collected and sealed in plastic tubes ten feet in length and about five inches in diameter, and then transported to the University for examination. This sampling method makes it possible to use the talents and facilities of the landlocked U of I for oceanographic research.

Professor Richards heads an interdisciplinary research team organized to find accurate ways to classify the engineering properties of the ocean bottom. For years the installation of vital military, scientific, and industrial structures on the ocean floor has been held back by lack of knowledge of the engineering properties of the sea soil. Time and again valuable equipment has been lowered to the sea bottom and lost in the watery sediment. Soil density, shear strength, and porosity — as important and as variable in underwater construction as they are in dry land construction — have been considerably more difficult to measure because they lie beneath thousands of feet of salt water.

The research project will provide an opportunity for at-sea testing of a number of measuring devices developed by the participating engineers. Designs for a gamma-ray probe to determine density of the ocean sediment are being completed by Professor Kenneth Preiss of the Departments of Nuclear and Civil Engineering. The probe, which will be lowered by cable from a ship into the ocean floor, is shaped like a giant two-pronged fork. One prong contains a pea-sized quantity of radioactive cesium; the other a radiation detector which counts and relays the number of particles it detects to a recorder aboard ship. Since fewer radioactive particles can penetrate dense soil than light soil, the particle count rate is lower in denser sediment.

A laboratory adaptation of the probe is already being used to measure the densities of core samples. In this model the two prongs are replaced with a two-barrelled carriage, containing the source and the detector, which is driven in tracks along the sampling tubes.

Other instruments being developed are the vane-shear probe for measuring shear strength of the ocean floor, and the piezometer. The piezometer, to be tested at sea this summer, will compare water pressure within the ocean soil with that of the water above it. The device will help determine if pressure in the soil has any bearing on the settling properties of the sea floor.

Studies on the floor of the ocean are conducted off the coast of Cape Cod, Massachusetts, from ships provided by the U.S. Department of Commerce. Ultimately Professor Richards and his colleagues hope to classify entire areas of the ocean floor so that the sea bottom can be mapped by its engineering characteristics. ◆

GIVE (FINANCIAL) CREDIT WHERE IT'S DUE

The initial demand for *Outline of Zetetics, A Study of Research and Artistic Activity,* by Joseph T. Tykociner, has been both encouraging and slightly troublesome.

Because the Engineering Publications Office acts only as a mailing center for the new book, order checks ($2.00 per copy) should be made out directly to Joseph T. Tykociner and mailed to 112 Engineering Hall, Urbana, Illinois 61801, so that orders can be filled promptly. ◆

ALUMNUS ESTABLISHES LOAN FUND FOR CIVIL ENGINEERING STUDENTS

Colonel William P. Jones, Jr., U.S. Army, Illinois graduate of 1932, has given the University $5,800 to establish a loan fund in honor and memory of the late Professor John S. Crandell of the Department of Civil Engineering. The fund will be known as the "John S. Crandell Loan Fund for Civil Engineering Students," available both to undergraduate and graduate students in that field. Colonel Jones studied under Professor Crandell. ◆

SECOND BOOST ANNOUNCED FOR UNDERGRADUATE EDUCATION

Encouragement of better teaching for engineering undergraduates has resulted in eight Undergraduate Instructional Awards to University of Illinois engineering teachers. The Awards program, initiated last year, provides full-time salary for two summer months for instructors whose proposals for improving undergraduate instruction are judged promising by the office of the University Provost.

This year's awards were made to Robert W. Bohl, Professor of Metallurgical Engineering; Edward R. Holley, Assistant Professor of Civil Engineering; Benjamin C. Kuo, Associate Professor of Electrical Engineering; Carl S. Larson, Assistant Professor of Mechanical Engineering; David S. Lieberman, Professor of Physical Metallurgy; Wayne L. Shick, Professor of General Engineering; Robert A. White, Assistant Professor of Mechanical Engineering; and Hans J. Zimmermann, Assistant Professor of Industrial Administration.

Three special awards of $1,000 each — one at the Chicago Circle campus and two at the Urbana campus — are made yearly to the most outstanding applicants. ◆

THEY'VE GOT HIGH HOPES

If Electrical Engineering Professor S. A. Bowhill counts backwards with greater ease than forwards, it's only to be expected. As head of the University of Illinois rocket program, he is directing launchings in January, March, June, July, and November of this year from the United States, Canada, Puerto Rico, and Argentina.

The probes, backed by funds from the National Aeronautics and Space Administration and the U.S. Air Force, will continue research begun in 1963 into the composition and behavior of the ionosphere, a radio-reflective atmospheric region extending from 25 to 600 miles above the earth's surface. The zone is important in long-distance radio communication. Ions in this region can absorb radio signals before the electrons have a chance to reflect them back to earth.

The January firings from Wallops Island, Virginia, attempted to explain the sporadic changes in the lowest layer of the ionosphere, a layer which on some winter days is two to three times as intensely ionized as it is on others (see the January issue of *Outlook*).

In March the Aurora Borealis was investigated by a rocket launched from Fort Churchill on Canada's Hudson Bay. Visible at night as the "Northern Lights," the Aurora produces an intense layer of signal-absorbing ions in the daylight hours. This absorption is so great — ten to twenty times higher than that at lower latitudes — that fundamental changes in instruments are necessary to gather the data.

June firings will be carried out at Wallops Island and in Puerto Rico. The Puerto Rican rocket shot will gather data on electron densities and temperatures in the ionosphere at heights of 100 miles for comparison with information recorded by Cornell University's ground facilities in the same area. The other probe will continue studies of the effect of dawn on the ionosphere (see the November, 1964, issue of *Outlook*).

July's entries will be fired at sunset in order to observe ionospheric changes as the sun goes down. The November firing, although still tentative, is planned to coincide with a November 12 total eclipse of the sun in South America. The launch will take place with the help of scientists from that area.

A field station, scheduled to begin operations in February, is being constructed near the Urbana campus. From its giant antenna, composed of sixteen smaller antennae in four square arrays, radio signals will be transmitted into the ionosphere. In this way, absorption and reflection data can be collected indicating daily and seasonal changes of ions in the ionosphere. Their success in this search for clues to the mysteries of the ionosphere might earn Professor Bowhill's group a space-age nickname — the rocket squad. ◆

STIRLING NUMBER TABLE PUBLISHED

Table of the Stirling Numbers of the Second Kind, by Alex M. Andrew and with an introduction by Heinz Von Foerster, is available from the Engineering Publications Office at a cost of $2.00. The Table was prepared by the U of I Biological Computer Laboratory, and is the only printed major table of the Stirling numbers of the second kind, $S(n,k)$ calculated for n,k up to 100 and for values of $S(n,k)$ smaller than or equal to $10^{109} - 1$; that is, up to 109 digits.

The Table fills a long-felt gap in the availability of combinatorial numbers for a large category of problems of general interest. ◆

ENGINEERING TEACHER PROGRAM RESULTS

Of 60 men who have earned doctoral degrees from the University of Illinois College of Engineering in a special program to develop engineering teachers, 49 now are teaching in universities, Professor Seichi Konzo, chairman of the committee in charge of the program, has reported. The program has been operating since 1961 under a $585,000 grant from the Ford Foundation. Money has been allocated to doctoral students on a forgivable basis under which the loan is cancelled after five years of teaching. ◆

COLLEGE OF ENGINEERING HONORS ALUMNI AND STUDENTS

In an awards convocation held May 3, six College of Engineering alumni were honored for outstanding leadership and contributions to engineering, and four students received recognition for scholastic achievement.

Recipients of the Alumni Honor Award for Distinguished Service in Engineering were: Raymond E. Davis, Director, Emeritus, Engineering Materials Laboratory, University of California, Berkeley; Henry T. Heald, Partner, Heald, Hobson and Associates, New York; Hjalmar W. Johnson, Vice-President, Retired, Planning and Research, Inland Steel Company, Chicago; Rudolph E. Peterson, Manager, Mechanics Department, Westinghouse Research and Development Center, Pittsburgh, Pennsylvania; Fred B. Seely, Professor and Head of Department, Emeritus, Theoretical and Applied Mechanics, University of Illinois; and Clifford S. Strike, Partner, Strike and Meissner, New York.

Four special awards are granted annually by the College of Engineering to engineering juniors and seniors for unusual scholastic achievement as well as participation in technical and professional societies and other campus activities. This year the Hamilton Watch Company Award was presented to Larry Pflederer, senior in civil engineering; the Honeywell Award, to George W. Schwarz, Jr., junior in mechanical engineering; the Harvey H. Jordan Award, to James M. Davis, senior in electrical engineering; and the Lisle Abbott Rose Memorial Award, to David L. Keune, senior in electrical engineering. ◆

PEOPLE AND PLACES

Professor **James White**, Dyson Professor of Ceramics Technology, University of Sheffield, England, has been appointed Visiting Professor in the Department of Ceramic Engineering at the University of Illinois. He is presenting a special series of 15 lectures on high temperature chemistry in ceramic materials and processes.

A report by a Special Commission on Weather Modification issued recently by the National Science Foundation recommends increasing Federal expenditures for research, development, and other weather modification activities. Professor **John Bardeen** of the Departments of Electrical Engineering and Physics was vice-chairman of the Commission.

The late Professor Andrew **I. Andrews**, former head of the University of Illinois Department of Ceramic Engineering, has been named to receive the nineteenth annual Albert Bleininger Memorial Award and Scroll for distinguished achievement in the field of ceramics.

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AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 7, NO. 6, JUNE 1966

In the order listed, this issue contains articles on the following subjects:

HUM A FEW BARS AND HE'LL FAKE IT

Musical tones different from those of any existing instrument may come from research at the University of Illinois, where Professor James W. Beauchamp of the Department of Electrical Engineering is undertaking a detailed and precise mathematical analysis of musical tones. He will use high-speed electronic computers and the electronic facilities of the University's School of Music. The analysis will be important to musicians, composers, teachers, engineers, and manufacturers.

Beauchamp will seek answers to these and other questions: What distinguishes tones produced by different instruments? How are these affected by pitch, loudness, playing style, and performer? What distinguishes good from poor tone quality? And what properties interest the human ear? Answers obtained by mathematically taking musical tones apart could provide a way to mathematically compose music with completely new tone qualities.

The Magnavox Company will support this research with $20,000 a year for three years and provide an electronic organ for use in the study. The firm has provided $10,000 a year for the past three years for music research at Illinois under Professor Lejaren A. Hiller, Jr., of the School of Music. This pioneer in the application of electronics to music has developed a unique center for study of electronic and computer music and analytical studies of sound. Related work in this area was reported in the November issue of *Outlook*.

Hiller's use of the University's Illiac I and IBM 7094 computers for musical composition is well known, but he has also performed extensive research in musical acoustics and experimental music. Beauchamp has worked with him for several years, during which time Beauchamp invented a new electronic device called the Harmonic Tone Generator which provides means to add and individually control overtones of a harmonic series to form a complex musical tone. ◆

COLD CUTS

The bounce made rubber famous, but it also made it exasperatingly hard to work with. Cutting rubber parts, for instance, is ordinarily a slow, difficult, imprecise operation. Now a study at the University of Illinois has shown that rubber can be machined like metal quite accurately if it is first cooled to supercold temperatures.

Professor K. J. Trigger of the Department of Mechanical and Industrial Engineering developed this cold machining technique to cut rubber printing plates. Such plates are used for printing on hard, grained, or rough surfaces where conventional type and etchings would not hold up. These rubber plates are presently carved by hand at room temperature. Total time per plate for this technique is three hours, and the work must be done by skilled craftsmen. The new technique could cut the time by two thirds, and one man with a little experience could keep several machines running simultaneously.

Professor Trigger first tested this technique by taking a rubber mat to the refrigeration room of a local dairy; after the mat was cold enough to be brittle, he drew a cutting tool across its surface. The chip produced indicated that the cooled material could be machined on a lathe.

Next, a special lathe normally used to engrave plastic printing plates was loaned by Graphic Electronics of La Salle, Illinois. This lathe, which automatically copies a black-on-white drawing of the image to be engraved, was adapted to the cold-cutting process by adding a liquid-nitrogen cooling device.

Currently Werner Diehl, a graduate assistant in Professor Trigger's group, is investigating the machining properties of various types of rubber cooled below the point at which it grows brittle. With this low-temperature information, the best material for the cold machining process can be selected.

If this technique seems unusual, Professor Trigger's latest idea is even more bizarre. He plans to replace the lathe's standard cutting tool with an air-driven burr like the ones used by dentists, in the hope that this high-speed tool will cut more smoothly and deeply. Apparently the main prerequisite to solving rubber problems is to have an elastic imagination. ◆

TUNNEL VISION GETS BETTER

The first flight (and the second, and perhaps the next few hundred) of any modern aircraft or missile does not involve test-pilot heroics or a dramatic takeoff from a secret airfield. Far more likely, the vehicle will fly first in miniature inside a wind tunnel, with an engineer at the controls.

But with faster airplanes come faster tunnels — and bigger test problems. No longer are comparative breezes of a few hundred miles per hour adequate; most modern wind tunnel tests involve blasting jets of gas at infernal temperatures. Accurate analysis of the speed and density of the gas during such flight simulations is difficult indeed.

A University of Illinois researcher may have developed an improved way to make these measurements. Professor J. L. Loth of the Department of Aeronautical and Astronautical Engineering has designed and tested a velocity and density probe which can tell the operator just what is happening inside a high-velocity wind tunnel.

The instrument, which is water cooled to keep it from burning in the 20,000-degree heat, uses the innovation of trapping part of the speeding gas and, from measurements of the mass, momentum, and energy content of the sample, allows the researcher to determine the exact conditions under which the test model is "flying."

The design of the probe was complicated by the fact that it has to endure destructive heating, must "swallow" the supersonic gas sample, and has to be small enough not to block the main gas flow.

The searing exhaust of a plasma jet creates a pattern of shock waves and turbulence from the nose of this special wind tunnel velocity and density probe. The instrument was designed by U of I Aeronautical Engineering Professor J. L. Loth to provide information on tests conducted at many times the speed of sound.

Later this year the probe will be added to the instrumentation of the University's new hypersonic wind tunnel, which is capable of test speeds up to twelve times the speed of sound. From facilities like this will come the knowledge engineers need to cope with the blazing speeds of tomorrow's travel. ◆

A DEEP DISCUSSION

Pioneers in the new field of marine soil mechanics met May 1-4 at the University of Illinois for the world's first Research Conference on Marine Geotechnique. Thirty scientists, including seven from foreign countries, took part in the conference at Allerton House, the U of I conference center. Present were almost all the men today engaged in the field of marine soil mechanics, which began little more than a decade ago.

While less is known about the bottom of the ocean than about the surface of the moon, knowledge of the strength of the ocean floor is essential for establishing undersea structures where men may live for long periods of time, for offshore oil drilling or mineral recovery, for pipelines, marine telephone cables, and safety of submarines which may wish to rest on the bottom.

The conference was sponsored by the University of Illinois and the Institute for Oceanography of the new Environmental Science Services Administration in the U.S. Department of Commerce. Professor Adrian F. Richards of the Departments of Geology and Civil Engineering organized the meeting. He was assisted by P. Wyman Harrison of the Institute for Oceanography's Land and Sea Interaction Laboratory at Norfolk, Virginia.

Richards, who recently came to Illinois, is developing a comprehensive laboratory, reported in the May issue of *Outlook,* to study marine soil mechanics as part of one of the most modern laboratories for marine sedimentology in the country. This project is in cooperation with the U.S. Institute of Oceanography, Office of Naval Research, Navy Bureau of Yards and Docks, and the National Science Foundation.

The University of Illinois, internationally known for research in soil mechanics on land, has extended its work to the sea bottom. Though the University is far from deep water, it is considered the birthplace of submarine geology through the investigations of Professor Francis P. Shepard while he was on the U of I staff from 1922 to 1945. ◆

THEY'RE IN HOT WATER

Archimedes was taking a bath when the principle of buoyancy occurred to him, and he shouted "Eureka!" Today, at the University of Illinois, volunteers are soaking in baths to study another principle — that of heat-induced sweating. Professor B. A. Hertig of the Mechanical and Industrial Engineering Department, in charge of this investigation, hopes to learn more about the physiology of sweating and the various conditions which affect perspiration rates.

Results of this study, conducted in the Physical Environment Laboratory, indicate a definite relationship between inhibition of sweating and the amount of moisture on the surface of the skin. When the test subject is immersed to his neck in a hot bath for several hours, his perspiration rate will increase for a time and then begin to decline. Perspiration rates appear to be dependent on immersion time as well as bath temperature. While tests in the past have attempted to explain this phenomenon in terms of sweat gland fatigue or decline in moisture content of the body, these explanations don't hold water under the conditions of the present study.

Professor Hertig's tests have involved a limited number of subjects, but the theory that moisture on the skin impedes perspiration has been borne out. Other tests show that subjects who have been acclimated to heat before entering the bath begin perspiring at a lower temperature in the bath than those who are unacclimated. Results also indicate that immersion in brine (10 to 15 per cent salt by weight) will prevent decline in perspiration.

Future tests may involve baths of silicone oil. In this way the moisture lost by the subject could be measured directly, since water doesn't mix with this oil. Current tests in water baths require that the subject be weighed at periodic intervals during the tests and corrections made for water consumed during his time in the bath.

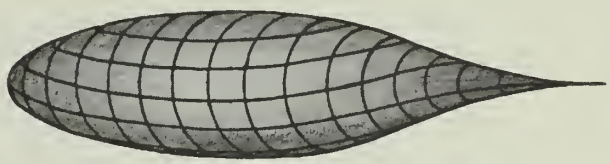
A better understanding of the phenomenon of sweating is important in situations where water supply is a problem, as in military operations and space flights. And when the mechanisms involved in sweating become clear, perhaps Professor Hertig can throw in the towel. ◆

WILL AUTOMATION DISPLACE GIRL-WATCHERS?

Men's preferences about shapes sometimes differ, but at the University of Illinois a researcher is settling questions of that kind scientifically — with a computer. Professor Will J. Worley of the Department of Theoretical and Applied Mechanics is directing a study of a special family of geometric shapes for the National Aeronautics and Space Administration, sponsor of the research.

The shapes, which find use in structural shells for fuel tanks, aircraft components, ships, and space craft, are derived from equations only slightly different from those used to plot ordinary ellipses. Although studied as early as the 1830's by Peter Dirichlet, a famous German mathematician, the equations lay essentially dormant for more than 100 years until the digital computer made their extended use practical. Now Professor Morris Stern and Dr. Han-chung Wang have compared these shell shapes, so that designers will be able to choose precisely the proper contours for a variety of applications. For a rocket fuel tank required to fit into a compartment of fixed dimensions, for example, an engineer might consult their results to help him select the tank shape with the best combination of weight, capacity, and strength.

Somewhat reassuringly, the computer has so far only looked at these relatively simple configurations. It seems unlikely that it could influence anyone's thinking about a *really* interesting shape, anyway. ◆



This streamlined shape is one possibility among a family of special shell shapes under a computer investigation directed by U of I Professor Will J. Worley. The shells, whose properties he is tabulating, might be useful as fuel tanks, submarine hulls, and other vessels.

NEWMARK NAMED TO NATIONAL ACADEMY OF SCIENCES

Election of Professor Nathan M. Newmark, Head of the Department of Civil Engineering, to the National Academy of Sciences, brings to 19 the number of University of Illinois faculty members honored by selection as America's foremost scientists in their fields. Among them is Professor Frederick Seitz, University of Illinois physicist, who is president of the Academy.

Newmark is also a founding member of the National Academy of Engineering, recently established companion organization to the National Academy of Sciences, in which the University of Illinois has three members.

Newmark's career has been devoted to research and instruction in structural engineering. The recipient of many honors, he was given the Vincent Bendix Award for Engineering Research from the American Society for Engineering Education in 1961. In 1958 he received the Norman Medal, highest award of the American Society of Civil Engineers, and the Society's Ernest E. Howard Award for contributions in structural engineering and design of the earthquake-resistant Latino-Americana Tower in Mexico City.

In the same year this 43-story structure received a special award from the American Institute of Steel Construction because of its successful resistance to the major earthquake of July, 1957. ◆

A PLUG FOR THE OTHER NETWORK

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You will want to be in on the changes, too. To keep up with information concerning engineering education and research on the Circle Campus, send for their free quarterly newsletter, *Chicago Circle Engineering*. Subscriptions are available upon request from the University of Illinois at Chicago Circle, Box 4348, Chicago, Illinois 60680. ◆

PEOPLE AND PLACES

Profcssor **William A. Oliver** of the University of Illinois Department of Civil Engineering has been awarded the Industrial Cooperation Award. The Award is prescnted by the Forest Products Association "To that individual, firm or organization not directly a part of the forest products industry, which through cooperative efforts, programs and actions, has materially assisted the forest products industry by independent or cooperative action in seeking solutions to problems of mutual interest or of benefit solely to the forest products industry."

A Certification of Appreciation for a decade of service to the Illinois Scientific Advisory Committee of the Selective Service System has been presented to Dean **William L. Everitt** of the College of Engineering. The citation was made "in grateful recognition of valuable services contributed to the nation and the Selective Service System in the administration of the Universal Military Training and Service Act."

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 7, NO. 7, SEPTEMBER 1966

In the order listed, this issue contains articles on the following subjects:

MONEY FOR A RAINY YEAR

Pioneering research on the mechanics of surface runoff of rainfall will be carried on at the University of Illinois, under a $116,700 National Science Foundation grant. Although engineers have considerable information on channel hydraulics — the flow of water in streams and rivers — there has been almost no research on watershed hydraulics — the varying factors affecting rain and runoff before the water enters streams.

To study these factors under controlled conditions, the University of Illinois has a unique, large, laboratory rainstorm-making machine, built during the past three years under another NSF grant. Professor Ven Te Chow of the University's Department of Civil Engineering is in charge of the research.

The machine has 1,600 square feet of rain-making area. Under this area a three-dimensional testing surface can be built to any shape, slope, or roughness. The controlled rainstorm can be of selected intensity, cover all or part of the area, move across it, and vary as desired. An electronic computer and other devices control the pattern of rainfall through 100 valves and record runoff and other data.

The system is used for both research and teaching hydrology. In the past three years, 36 undergraduate students have worked with it and six graduate students have used it in thesis research. More than 300 engineers and scientists from America and abroad have come to Illinois to see the machine. Its use is in the high-priority problem areas of the proposed United States program for the International Hydrological Decade. ◆

BALL-BEARING WATER

Engineering research sometimes looks backward as well as forward. Modern investigators are reexamining many familiar phenomena in much greater detail than in the past, using the improved instrumentation and new knowledge that is constantly being made available. At the University of Illinois this trend is being continued in a project of the Hydraulic Engineering Laboratory of the Department of Civil Engineering. The project, sponsored by the Water Resources Center, involves a closer examination of the water velocities near the boundary of an open channel.

The object of the experiment, which is directed by Professors H. G. Wenzel and V. T. Chow, is to determine how the velocity profile varies around the wetted perimeter of the channel. This knowledge can then be used to determine the distribution of shear stress or "drag" force which exists between the water and the channel wall. Engineers designing storm sewer, drainage, or irrigation channels usually employ an average value of the boundary shear stress. In many cases, however, knowledge of the actual distribution will permit a more intelligent channel design, particularly if sediment transport is important.

The experimental technique is unusual: the researchers use a microscope to view the motion of tiny polystyrene spheres, 20 millionths of an inch in diameter, as they drift along the water-filled channel. These spheres act as tracers. Photomicrographs taken of them enable

engineers to compute the velocity. Presently two-dimensional studies are being made, but three-dimensional boundary studies are planned.

This technique has the distinct advantage of making measurements possible without disturbing the flow in any way, and it shows potential for becoming an extremely useful means of flow visualization and measurement. ◆

This time exposure, token of microscopic plastic spheres moving in on open woter-filled chonnel, shows the motion of woter neor the chonnel boundory. The study, directed by Professors H. G. Wenzel ond V. T. Chow, is being conducted ot the Hydroulic Engineering Loborotory of the University of Illinois Deportment of Civil Engineering.

LAB EARNS ITS OWN WAY TO MODERNIZATION

A giant step toward modernization of the Metal Casting Laboratory of the Department of Mechanical and Industrial Engineering at the University of Illinois was taken recently when a new induction furnace was installed. This new addition to the teaching and research capabilities was obtained through the efforts of Professor James L. Leach, who heads the Laboratory. The 50-kilowatt induction furnace is electrically heated, and can be used to melt a wide variety of metals, including alloy steel, cast iron, and nonferrous metals.

The induction furnace itself, valued at $1,800, was donated to the laboratory by the Wagner Casting Company of Decatur, Illinois. It is estimated that the remainder of the equipment, consisting of transformer, switch gear, and installation, will cost an additional $17,000.

The financing of this new equipment is a story in itself. Neat cast-aluminum signs identify over one hundred campus buildings. The letters for the signs were cast by Norman G. Donze, Senior Foundry Molder, and proceeds from the signs were devoted to this new capital improvement for the Laboratory, so that no outside funds were required for this self-help improvement. ◆

FOURTH ANNUAL REVIEW OF ELECTRONICS ANNOUNCED

Three major areas of electronics in which the University of Illinois is a leader will be presented November seventh and eighth in the University's Fourth Annual Review of Electronics.

Space electronics, solid state electronics, and computers will be presented in technical papers, discussions, and laboratory visits. Professor Wolfgang J. Poppelbaum, conference chairman, has announced that more than 250 persons from across the nation are expected. ◆

'66 ENGINEERING GRADUATES — WHERE THEY WENT AND WHY

A report by Pauline Chapman, Placement Director of the University of Illinois College of Engineering, shows that the average starting salary for June engineering graduates was $688.15 per month, the highest ever and over $40 per month higher than the average of 1965 graduates. Maintaining a trend common in recent classes, only half the new graduates went directly to jobs. The remainder entered graduate study, military service, or other activities.

In ten years the percentage of students entering graduate study has more than doubled, and the starting salary for engineering graduates has increased by almost $250 a month. ◆

ILLIAC IV CONTRACTS AWARDED

Three contracts have been awarded by the University of Illinois for design studies on development of ILLIAC IV, a large-scale, highly parallel electronic computer to be built in a project involving more than eight million dollars.

The contracts are to the Radio Corporation of America, Burroughs Corporation, and Univac. These firms will work with Professor Daniel L. Slotnick of the Department of Computer Science on studies which will terminate in the awarding of a contract for construction of the computer and its installation at the University. The project is financed by the Department of Defense through the Air Force Rome Air Development Center, and is planned as a joint effort between the University and industry.

ILLIAC IV will pioneer a new concept in special purpose computer organization developed by Slotnick, who is in charge of the project. The machine is planned for more than one billion computations a second, with a small number of control units operating a very large number — initially several hundred — of linked arithmetic and data storage units. With this organization, ILLIAC IV will be as much as fifty times faster than any other electronic computer now contemplated. ◆

NEW ENGINEERING SCHOLARSHIP

A new scholarship in engineering has been established at the University of Illinois from an $18,000 bequest by Miss Hilda Josephine Alseth, who served more than a third of a century as engineering librarian. Miss Alseth, who died in 1964 at the age of 78 years, joined the University staff in 1918 and worked as an assistant in the engineering library for one year. She was promoted to librarian the following year and continued in that position until retirement in 1954.

Undergraduates in any branch of engineering will be eligible for the Hilda J. Alseth Scholarship, to be awarded annually through the University of Illinois Foundation. ◆

BRAINY BUSINESS

For as long as anyone can remember, people have been interested in one subject — people. There are two common ways of learning about people: watching people, or watching something that behaves like people.

M. E. Clark, Professor of Theoretical and Applied Mechanics at the University of Illinois, is using the second method to learn about the flow in an unusual network of blood vessels in the brain called the "circle of Willis." Professor Clark is heading a study which uses a bigger-than-life latex model of the network to find out more about this part of the human circulatory system, which distributes blood from the heart to various regions of the brain.

Animal tests with the real circle of Willis are extremely difficult to perform, since its position at the base of the brain makes it nearly inaccessible. Any surgery performed to make the circle more accessible changes the pressures and flows that are being investigated.

In the past, studies have been made using steady flow models with inflexible vessels or electronic computer analogues of such models. The usefulness of the results was limited because they ignored the flexibility of real blood vessels and the pulses in real blood flow. Professor Clark's newest series of experiments will use a model which behaves more nearly like the real circle, and an oscillating fluid flow more like that from the heart.

Professor M. E. Clark of the U of I Department of Theoretical and Applied Mechanics compares an early rigid model of the circle of Willis, a blood vessel in the brain, with a drawing of the actual structure. His research into the behavior of this part of the circulatory system now centers on a rubber model which more closely simulates the characteristics of real blood vessels.

From this and other studies may eventually come solutions to problems of cerebral circulation and, more immediately, an insight into the workings of that circle in everyone's brain. ◆

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LOOKING FORWARD AND UP

The National Science Foundation has awarded the University of Illinois a $51,000 grant to determine the direction which aeronomic research on the middle atmosphere may take in the next ten years.

The middle atmosphere is the area roughly 50 to 120 miles above the earth's surface. This region contains clouds of free electrons and the often-spectacular "northern lights" or Aurora Borealis. In addition, this region screens much of the sun's ultraviolet rays from the earth. Scientists are interested in the nature of ionospheric ions, the measurement of their masses, and the rates at which ion clouds form and disappear.

Heading the 15-month study will be Professor Sidney A. Bowhill and Professor John V. Evans. Bowhill is in charge of the U of I Aeronomy Laboratory and is internationally known in this field. Evans, from Millstone Ionospheric Observatory of the Massachusetts Institute of Technology, will be a visiting professor this fall.

A committee has been formed by Big Ten schools and the University of Chicago to consider establishment of aeronomy facilities in the Midwest to aid national research in this field. A facility of this type would permit study of ionospheric layers and their irregularities, gravity wave, tidal, geomagnetic, and solar flare effects. ◆

PEOPLE AND PLACES

New officers of the American Society of Agricultural Engineers include, as vice president, **F. B. Lanham,** head of the Department of Agricultural Engineering, and as a director, **B. A. Jones, Jr.,** Professor of Agricultural Engineering, University of Illinois.

Five men from the faculty of the University of Illinois will be members of the United States Delegation to the Union Radio Scientific Internationale 15th General Assembly, September 5 to 15, in Munich, Germany. Professor **Edward C. Jordan,** head of the University's Department of Electrical Engineering, will be vice chairman of the U.S. delegation. Others will be Professor **Sidney A. Bowhill** and Professor **G. A. Deschamps** of Electrical Engineering, Professor **John B. Evans** of the Massachusetts Institute of Technology, Visiting Professor of Electrical Engineering at Illinois, and Professor George W. Swenson, Jr., of the departments of Electrical Engineering and Astronomy at Illinois.

Professor Swenson has also been awarded a two-year leave of absence by the Board of Trustees. He has assumed full-time duties as Chairman of the Design Group for the Very Large Array, an extremely large radio telescope being planned by the National Radio Astronomy Observatory, Charlottesville, Virginia. He will return to Urbana two days per month to advise the radio astronomy program here.

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BRAIN LOAN

Although the University of Illinois' PLATO has been considered one of the most advanced automatic teaching systems in the country, it never has had a brain for more than three or four hours a day. Now, thanks to the Control Data Corporation, PLATO (Programmed Logic for Automatic Teaching Operations) has been loaned a brain solely for its own use in the form of a CDC 1604 computer, a line printer, and a tape drive unit.

In the past the computer-assisted instruction project has been limited to about 20 per cent of the available time on another CDC 1604, which also served the rest of the projects in the Coordinated Science Laboratory. The additional computer, originally valued at one million dollars, was loaned so that the PLATO project could undergo a major expansion. The number of experimental courses taught with the computer-based system will be increased from three to twelve. Other groups from the Graduate College, the College of Education, the Department of Psychology, and departments in the College of Engineering which have been cooperating in the research of the project will also be able to expand their activities.

Because work in the Coordinated Science Laboratory is sponsored primarily by federal funds, the loan to PLATO of this high-speed, general purpose computer system by the Control Data Corporation represents the first major support of a CSL project by industry. ◆

IN THE MAIN STREAM: FLUID-JET CONTROLS

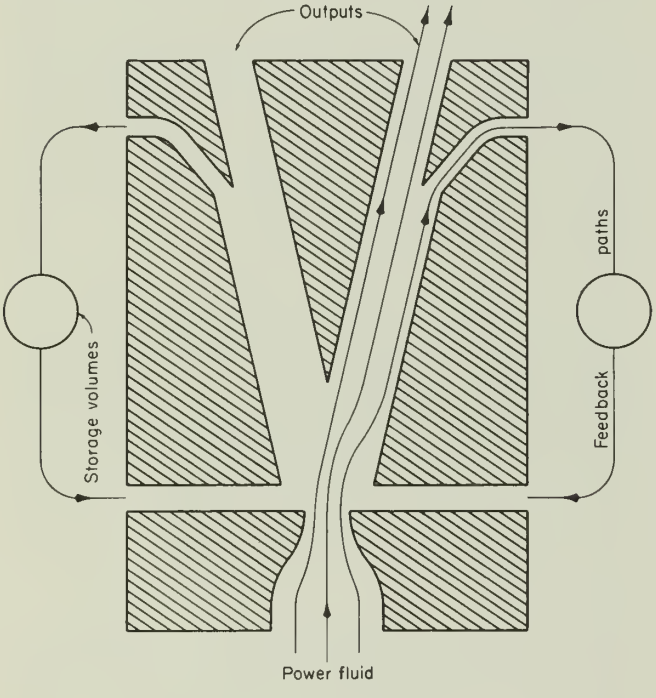
The unlucky soul for whom pitchers always seem to pour from the bottom can take heart. At least he's demonstrating a useful scientific occurrence, the Coanda effect. The adhesion of a moving stream to a solid surface is a little-understood phenomenon which appears to hold true for all fluids. The effect forms the basis for the new engineering field of fluid-jet controls and is the object of a research project in the University of Illinois Mechanical Engineering Department.

Some very promising applications are in the field of pneumatic control, in missile steering systems, and in computer logic elements. Unlike conventional control systems, fluid-jet controls have no moving parts and are not influenced by environmental conditions. Durable, they nevertheless have a potential for sensitivity and precision equal to their mechanical counterparts. They can run on ambient air or any other fluid and can vary from postage-stamp-sized to foot-square laboratory models.

Although fluid-jet controls of one variety or another are already on the market, little is known about why they work. The U of I mechanical engineers, under the direction of Professor W. L. Chow, have set out to understand the principles which determine their behavior.

Their present research centers around the construction and study of a fluid-jet oscillator and fluid-jet amplifier. In the oscillator (see diagram and picture), a jet of air in an enclosed channel adheres to either the right or left wall because of the Coanda effect. Part of this stream is tapped through the wall into a storage chamber from which it is returned to intersect the main flow at

Graduate ossistont J. D. McGeochy mokes pressure connections to o fluid-jet oscillotor built in the University of Illinois Deportment of Mechonicol Engineering. The reseorch is directed by Professor W. L. Chow. In the oscillotor, diogrommed below, oir enters from the bottom ond is diverted back ond forth into right ond left chonnels by smoll secondory streoms topped from the moin flow.



a point near its origin. Although the pressure of this secondary stream has diminished considerably, it is sufficient to deflect the main jet to the opposite wall of the channel, where the cycle is repeated in reverse. The back-and-forth deflection of the stream occurs from a few to thousands of times per second, depending mainly on the geometry of the channel and the size of the air storage chambers. When the two storage chambers are of different sizes, the oscillations are syncopated. The present Illinois model operates at six or seven cycles per second — a frequency comparable to that of a cat's purr. By discovering other variables affecting the frequency, the researchers hope to control the frequency with greater precision.

The fluid-jet amplifier works much like the oscillator, but is externally controlled rather than self-regulated. In it a low-velocity or low-pressure secondary jet is used to change or hold the direction of the main jet stream. The virtue of the amplifier, and of fluid-jet controls in general, is that a small cause provides a big effect. ◆

UNIVERSITY RANKED HIGH IN QUALITY AND QUANTITY

The University of Illinois ranks seventh among all universities of the nation in total volume of research, in a survey by *Industrial Research* magazine.

The report ranks the following ten institutions as national leaders in university research programs: California, Chicago, Cornell, Michigan, State University of New York, Massachusetts Institute of Technology, Illinois, Wisconsin, Stanford, and Pennsylvania. Illinois ranks third in engineering according to the survey, which covered 164 institutions.

In another study, published by the American Council on Education and entitled *An Assessment of Quality in Graduate Education*, Illinois was included among the highest rated universities. Ratings of the Departments of Electrical Engineering, Physics, Civil Engineering, Mechanical Engineering, and Chemical Engineering ranged from "distinguished" to "strong" in quality of the graduate faculty, and from "extremely attractive" to "attractive" in effectiveness of the graduate program. ◆

THE HUNTING SEASON

For employers seeking 1967 June graduates from the University of Illinois College of Engineering, all prime interview time already has been taken, Mrs. Pauline Chapman, Director of Placement of the College, has announced.

So that recruiters and students may have a fair opportunity to meet, the College holds the list of recruiters on the campus at one time to no more than 18. All days through Easter of next year already are filled. Most students select jobs before the spring vacation or as a result of visits to employers during the holiday, Mrs. Chapman explained. Only a few prospects are left after that time, though some recruiters do come.

Prime time for recruiters seeking midyear — February — engineering graduates from Illinois is before the Thanksgiving holiday, and all dates until then have been filled for some time. Mrs. Chapman also said that there are more summer jobs in industry available to engineering students from Illinois than there are students available to fill them. ◆

ELECTROMAGNETICS AND ANTENNAS FORUM ANNOUNCED

The second University of Illinois Forum on Electromagnetics and Antennas, to be held January 30 to February 3 at the U of I, has been announced by Professor Paul Mayes of the University's Department of Electrical Engineering. The first two days of the forum will be devoted to tutorial material on electromagnetics and antenna theory comparable to that taught in advanced undergraduate and graduate courses. The last three days will be devoted to review sessions on recent results in electromagnetics and antenna research in selected areas of timely interest. These will be presented by faculty of the University's Antenna Laboratory and outstanding speakers from outside the University. ◆

NSF SPONSORS EARTHQUAKE STUDIES

The National Science Foundation has provided $94,800 to the University of Illinois for research into making structures more resistant to earthquakes. The NSF has also provided funds for an "earthquake machine" to shake the scale model (1 inch = 1 foot) buildings. To compensate for the loss of mass in the scaled-down buildings, the shocks will come twelve times faster and stronger than those of an actual earthquake.

The earthquake machine can be programmed to duplicate the sequence of tremors of an actual quake. The action will be recorded by electronic gauges within the models and by high-speed movie cameras.

The project will be headed by Professors N. Norby Nielsen and Mete A. Sozen. Nielsen has been involved in research concerning dynamic response of multistory buildings since 1960. Sozen, who is internationally known as an expert on earthquake research, has travelled the world over studying damage from major shocks. Professor Nathan M. Newmark, head of the Civil Engineering Department and a world figure in the design of earthquake-resistant structures, will act as consultant. ◆

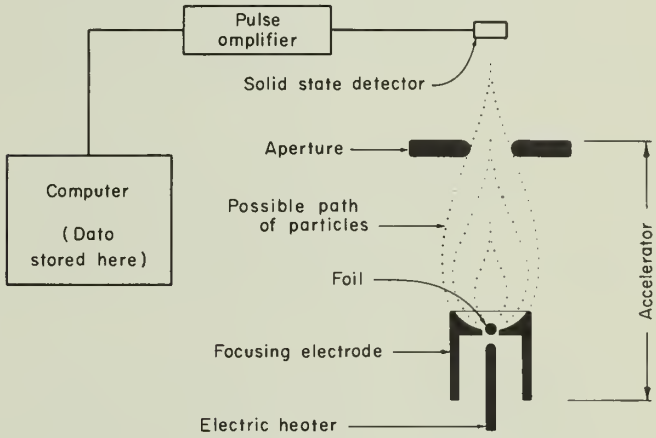
THE QUARK

Science long supposed that the "elementary" particles — protons, electrons, and neutrons — were the basic components of matter. But in 1962 a California Institute of Technology physicist, Murray Gell-Mann, used theoretical mathematics to show that particles even more fundamental than protons and neutrons may exist. These particles, whose charge he deduced to be plus or minus either one-third or two-thirds the charge of the electron, were dubbed "quarks" after a nonsense word used by James Joyce in *Finnegan's Wake.*

Now University of Illinois physicists directed by Professor Hans Frauenfelder are trying to prove whether quarks really exist. With a small custom-built particle accelerator, a particle detector, and a computer they identify the particles present in such materials as salt water, heavy water, meteorites, and limestone.

In the accelerator (see diagram) a piece of the material to be tested is heated, driving off any charged particles, including quarks. The particles are captured by the detector and identified according to their charge with the aid of the computer.

The mathematical model devised by Professor Gell-Mann has been successful in classifying the known fundamental particles in a particularly simple way. If Illinois' physicists do find quarks, they have nearly conclusive evidence that the model is valid. In addition, such a discovery could possibly mean the source of a previously unknown form of energy. ◆



A University af Illinais search far the "quark" — an uncanfirmed subatamic particle mare elementary than the pratan ar electran — is headed by physics Prafessar Hans Frauenfelder. Specimens af material thaught ta cantain quarks are maunted an fail, heated, and their charged particles driven by an acceleratar ta a detectar. Fram its charge the researchers, aided by a computer, can determine a particle's identity.

ENGINEERING SALARIES INCREASED BY HALF IN TEN YEARS

Beginning salaries of engineering graduates from the University of Illinois have increased 56 per cent in the last decade, according to the Engineering Placement Office. The average beginning salary is $688 a month for graduates with a B.S. in engineering. In 1956, this figure was $441.

None of the 306 engineering graduates from Illinois this June was unemployed two weeks prior to Commencement. Graduates stated that they looked first at the type of work they would be involved in, next at job location, and third, at the beginning salary. The percentage of engineers who elect to continue for graduate degrees has almost doubled since 1956. ◆

U OF I NUCLEAR REACTOR TO BE IMPROVED

The National Science Foundation, the Atomic Energy Commission, and the University of Illinois will be joint sponsors of a project which will make the six-year-old nuclear reactor at the U of I the equal of a million-dollar new machine. The work should be completed by the fall of 1967.

The reactor's pulsed power output will be increased from 1,000 to 5,000 megawatts. The steady-state power will be increased from 250 to 1,000 kilowatts (one megawatt) with a capacity for increases up to two megawatts.

The reactor interior will be rebuilt to provide improved facilities for the irradiation of materials. In addition, a new cooling system and control console will be built.

The reactor is used more than 45 hours per week as a research tool to study reactor systems, and to provide radioisotopes and irradiated materials for other fields from aeronautics to zoology. Such radioisotopes are used for research in over twenty departments of the University. ◆

PEOPLE AND PLACES

Dr. **Ven Te Chow,** Professor of Hydraulic Engineering, has been invited by the International Atomic Energy Agency to deliver an introductory address at the IAEA's Symposium on the Use of Radioisotopes to be held in Vienna, Austria, from November 14 to 18.

Professor **Ross J. Martin,** Director, University of Illinois Engineering Experiment Station, has been elected chairman of the Council of Associated Midwest Universities, Inc., an organization of 32 major universities and research institutions with headquarters at Argonne National Laboratory.

AMU was organized in 1958 to encourage and conduct research and education in all branches of science and to develop programs involving the use of Argonne and other laboratories by personnel from member institutions.

Professor **Clifton G. Bergeron,** Department of Ceramic Engineering, became a fellow of the American Ceramic Society during the organization's annual meeting, May 7 to 12, in Washington, D.C. Professor Bergeron, who has been on the Illinois faculty since 1957, was elected for his contributions to the profession, publications, and activity in the society.

President Lyndon B. Johnson has appointed Professor **Charles B. Slichter** of the Department of Physics to his Science Advisory Committee. Professor Slichter is one of five new appointees, and will serve a four-year term. Professor John Bardeen of the Departments of Electrical Engineering and Physics has just completed a term of service on the committee.

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ENGINEERING OUTLOOK
AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 7, NO. 9, NOVEMBER 1966

In the order listed, this issue contains articles on the following subjects:

MATERIALS RESEARCH: OLD LABELS ARE IMMATERIAL

A dramatic example of the interdisciplinary aspect of modern science is the new $8 million Materials Research Laboratory at the University of Illinois. Here physics joins metallurgy, chemistry, ceramics, and electrical engineering to investigate the properties of solid state materials.

Professor Robert J. Maurer, the Laboratory director, holds his professorship in the Department of Physics. The Laboratory was set up by Professor Frederick Seitz, formerly head of physics at Illinois and now president of the National Academy of Sciences. The Laboratory staff is linked to physics and other University departments through joint appointments.

The frontiers being attacked also cross the old lines between sciences. Physics touches chemistry and chemical engineering in such work as that of a chemist studying the effects of pressures so great that insulators become conductors of electricity. Physicists work with metallurgical engineers and ceramic engineers in developing entirely new materials unknown in nature, and with chemical engineers whose skills make possible the production of modern materials. Nuclear engineering, born from physics, is closely interlaced with its parent. Also close is electrical engineering, tremendously affected by physics devices such as the transistor and diode.

Facilities in the new Materials Research Laboratory building include a 3-million-volt Van de Graaff accelerator to produce high-energy electrons for the study of their effect on materials, a laboratory producing temperatures close to absolute zero, electron microscopes, superconducting magnets, X-ray diffraction equipment, lasers, isotope counters, and many other devices.

Through a pneumatic tube, materials can be shot directly into the heart of the University's nuclear reactor from the Laboratory in a fraction of a second. The physics library and other resources are only a few steps away through enclosed corridors between the two buildings. Theoretical computations and extensive analyses of data are made possible through the cooperation of the University's Department of Computer Science, whose equipment is among the finest in the world.

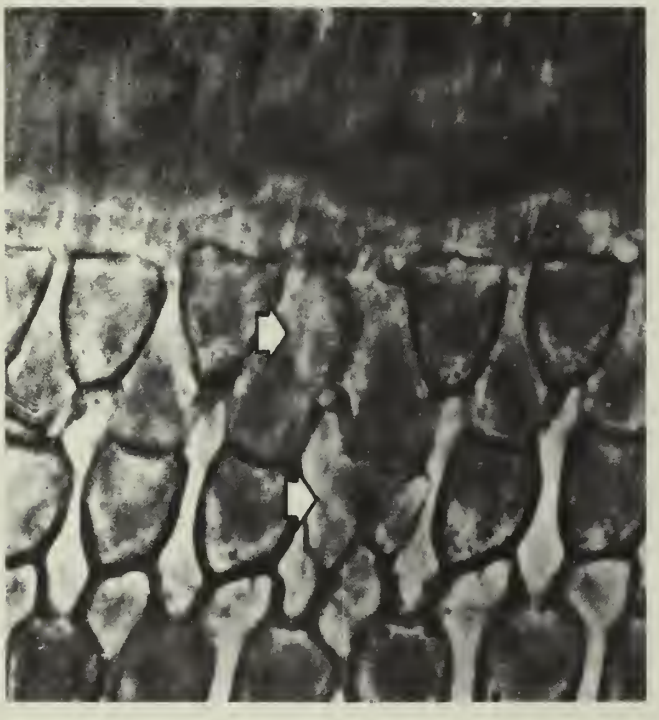
The Laboratory, with a budget of $3 million a year, is financed principally by the Atomic Energy Commission and the Department of Defense through its Advanced Research Projects Agency. The new facility will provide excellent educational opportunities. Maurer has forecast that, as the most certain product of the Materials Research Laboratory, the number of doctorates in materials science earned at Illinois will double. ◆

ENGINEERING STUDENTS HEAR GUEST LECTURERS

Experts in biochemistry, biophysics, environmental engineering, transportation, and oceanography presented a special series of lectures in conjunction with the University's basic engineering survey course, General Engineering 100. The lecture series was proposed by the Student-Faculty Liaison Committee to provide engineering freshmen with a comprehensive view of current engineering and scientific problems. At the end of the semester the series will be evaluated; if it is judged successful by the students, the lecture program will be continued next year. ◆

The cachlea, the spiral auditary argan af the inner ear, is the abject af a detailed study by Dr. H. W. Ades af the Electrical Engineering Department. The argan af Carti, in which the sensary cells are lacated, winds thraugh the ducts af the cachlea surraunded by the fluid af the inner ear.

In the phatamicragraph af the surface af the hair cells in the argan af Carti (belaw), twa damaged cells are indicated by arraws. As this picture illustrates, damage ar destructian af a single cell can be easily detected by abservatian; determining the cause af the defect is cansiderably mare difficult.



RACKET RESEARCH

The student who claims he cannot hear the French "r" and the bumpkin who admits he has "no ear" for music may both be right. Recent studies indicate that insensitivity to slight differences in sound or tone may be the result of damage or destruction of certain sensory cells of the inner ear — damage so insignificant that it cannot be detected by ordinary hearing tests.

Several methods of examining these hair-like cells for damage have been developed during the last six years by Dr. H. W. Ades of the U of I Electrical Engineering Department in conjunction with Dr. Hans Engstrom of the University of Göteborg in Sweden. Most of their tests have been made on small animals such as guinea pigs and squirrel monkeys; a few studies have been conducted on human tissue. The most reliable technique involves chemically treating the organ of Corti, where the hair cells are located, and examining the surface of the intact organ through a microscope.

Constant exposure to noise is probably the most persistent and important force acting on the inner ear, and may account for the gradual deterioration of hearing with age. The effect of different sounds — low-frequency, high-intensity tones in particular — is to be the subject of a new study which Ades and Engstrom will begin this month at a NASA research center at Langley Air Force Base in Virginia.

Squirrel monkeys will be subjected to tones with frequencies of less than 100 cycles per second and intensities around 130 decibels (a volume comparable to the sound of a helicopter hovering at low altitude). These rumbling tones, which are present in thunder and in the roar of a rocket at takeoff, are produced in the laboratory by a hydraulically operated plunger which will be located in the same room with the animals.

After the monkeys have been exposed to the tones for various lengths of time, they are to be sacrificed and the cell and nerve structure of their inner ears prepared for study. By examining these specimens, the researchers hope to learn in what way low-frequency tones damage the hair cells and where the damaged cells are located in the organ of Corti. Also they will try to determine how extensive the damage to the cells must be before the threshold of hearing is affected. Both are questions of vital importance in a noisy age of rocket launchings and high-powered weapons. ◆

PUBLIC HEALTH SERVICE MAKES THREE-YEAR GRANT TO ILLINOIS

The Agricultural Engineering Department of the University of Illinois has received a grant of $66,156 from the U.S. Public Health Service for the study of live-

stock waste management and sanitation. The three-year research project is headed by Assistant Professor Donald L. Day.

Aeration of livestock waste for odor control and stabilization will be the main phase of the investigation. The project will have interdisciplinary consultation from experts in animal science, sanitary engineering, agronomy, and the Health Service. ◆

MECHANIZED MOO

Eating is a matter of real importance to an animal with four stomachs. So keeping cattle well fed and their milk production high are matters of real importance to University of Illinois agricultural engineers.

According to Professor Elwood F. Olver and H. B. Puckett of the Department of Agricultural Engineering, automation in the feeding of dairy cattle has lagged behind that of other livestock feeding operations. To remedy the situation Olver and Puckett have collaborated with Dr. K. E. Harshbarger of the Dairy Science Department to build a modern dairy center equipped with a completely automatic feeding system.

The center is designed to handle the feeding, milking, and housing of 60 dairy cattle. The animals are divided into three feeding groups, according to the quantity of milk they produce. Electrically measured quantities of grass and corn silage and special feed mixtures are removed from storage bins, mixed, and conveyed to the feeding stations by augers. A 24-hour time clock regulates feed delivery, which may be as often as two hours or as infrequent as once a day. It is also possible to operate the equipment manually.

Built-in safety mechanisms insure proper feed delivery and prevent overloading of the conveyor motors. If a particular part of the equipment malfunctions persistently, the control system will shut off automatically and a warning signal will be set off.

This system takes a significant step toward reducing the time-consuming individual attention the dairyman must give his cattle. One man, using this new technique, should be able to handle enough high-producing cows to produce 500,000 to 700,000 pounds of milk annually; this compares with 350,000 pounds of milk without automation. Thus the dairy center should produce not only contented cows, but contented farmers. ◆

TRAFFIC-RELATED BULLETINS PUBLISHED

Traffic Linkage Patterns Between a Metropolitan Area and the Communities Within Its Region of Influence, by George W. Greenwood, discusses such factors as the spatial distribution of regional travel, volume of traffic interaction, and the degree of central city dominance in the generation of trips. The report, Bulletin 488, should be of special value to city planners and traffic engineers.

Bulletin 491 is a thorough study of *The Impact of Traffic on Residential Property Values and Retail Sales in Champaign-Urbana,* by Paul T. Kinney. Although the study is concerned with a specific urban area, it allows conclusions for a general pattern of vehicular traffic within a community. The study is supported with tables and figures, and includes the questionnaire used for interviewing residential property owners.

Bulletins 488 and 491 are available from the Engineering Publications Office at $4.00 each. ◆

ILLINOIS SHARES IN MILLION-DOLLAR ALCOA PROGRAM

As part of a new professorships program encompassing 16 schools in 10 states, the University of Illinois will receive a $60,000 grant from the Alcoa Foundation. The grant will be used for a professorship in electrical or mechanical engineering. By increasing communication between educators and practicing engineers of the Aluminum Company of America, the three-year program is designed to link education more closely with industry. The nationwide program of grants involves a total of more than one million dollars. ◆

PEOPLE AND PLACES

John J. Gilman, Professor of Physics and of Physical Metallurgy, presented the 1966 Edward DeMille Campbell Memorial Lecture at the American Society for Metals' National Metal Exposition and Congress on November 2 at McCormick Place in Chicago. The lecture is regarded as metallurgy's most honored technical presentation of the year.

Professors **Arthur J. Muehling** and **Roland F. Espenschied** of the University of Illinois Department of Agricultural Engineering were awarded blue ribbons for their entries in the American Society of Agricultural Engineers' annual extension exhibits competition. The contest stresses successful communications techniques.

Edwin L. Goldwasser, Professor of Physics at the University of Illinois, has been named chairman of the Division of Physical Sciences, National Research Council of the National Academy of Sciences. President of the Academy is Professor **Frederick Seitz,** another U of I physicist.

Civil Engineering Department head **Nathan M. Newmark** has been awarded honorary membership in the American Society of Civil Engineers. The presentation was made at the Society's awards luncheon on October 19 in Philadelphia. Newmark is the youngest man ever appointed by the board of directors for such membership.

Professor **Benjamin B. Ewing** has been named Director of the University of Illinois Water Resources Center. He replaces **Joseph P. Murtha,** Professor of Civil Engineering.

Named to the post of vice-chairman of the Council on Economic Growth of the Committee on Institutional Cooperation (Big Ten universities plus the University of Chicago) is **Daniel Alpert,** Dean of the Graduate School of the University of Illinois.

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The College of Engineering and the engineering profession mourn the death of Associate Dean Stanley H. Pierce, who died Sunday, October 30. Dean Pierce received his bachelor's degree in railway electrical engineering in 1932 from the University of Illinois, and joined the University faculty as a general engineering instructor in 1936. He earned his master's degree in electrical engineering in 1939. In 1946 he became assistant dean of the College, and in 1953 he was promoted to associate dean.

Dean Pierce's activities at Illinois included a broad range of responsibilities, from serving on the executive committee of the Engineering Experiment Station to work in student placement and high school relations. He served on University committees on admissions, new student week, military affairs, school and university relations, and computer utilization, to name only a few.

His readiness to assist them made Dean Pierce well known to engineering students. They showed their respect and admiration for him by dubbing him a Knight of St. Patrick in 1963.

Dean William L. Everitt of the College of Engineering paid him the following tribute: "At a time like this it is hard for me to be articulate about Stan Pierce. The initiative he showed in developing new approaches for college administration was copied by many institutions. He was in continual demand as a member or chairman of committees because he held for high standards when they were important, injected new ideas when they were needed, and yet knew when to compromise over nonessentials when that was the way to reach agreement to effect action. It is impossible for me to put into words how much we will miss him, but he will live in our hearts forever."

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ENGINEERING OUTLOOK
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 7, NO. 10, DECEMBER 1966

In the order listed, this issue contains articles on the following subjects:

A CLOSE LOOK AT THE NORTHERN LIGHTS

A rocket carrying research instruments for the University of Illinois has successfully probed the daytime aurora borealis. An Air Force "Black Brant" rocket carrying the instruments was fired from the Canadian National Research Council's range at Churchill, Manitoba, a main auroral activity area. Success of the venture, part of an ionosphere (upper atmosphere) research project in which the U of I has been involved since 1963, was reported from the launch site to Professor Sidney A. Bowhill of the Electrical Engineering Department.

The aurora, commonly known as the "northern lights," is seen most often at night. It also occurs in the daytime, however. The aurora is caused by the earth's magnetic field channeling electrons from space toward the poles. Daytime interaction of the sun and aurora creates an invisible radio-absorbing electron blanket which interferes with long-distance radio reception.

The Illinois instruments probed the interactions which cause the electron blanket as well as the sources of auroral electrons. The National Aeronautics and Space Administration provided ground-based equipment which was operated by M. Mukunda Rao, a visiting research associate to Illinois from India. ◆

HOT NUMBERS

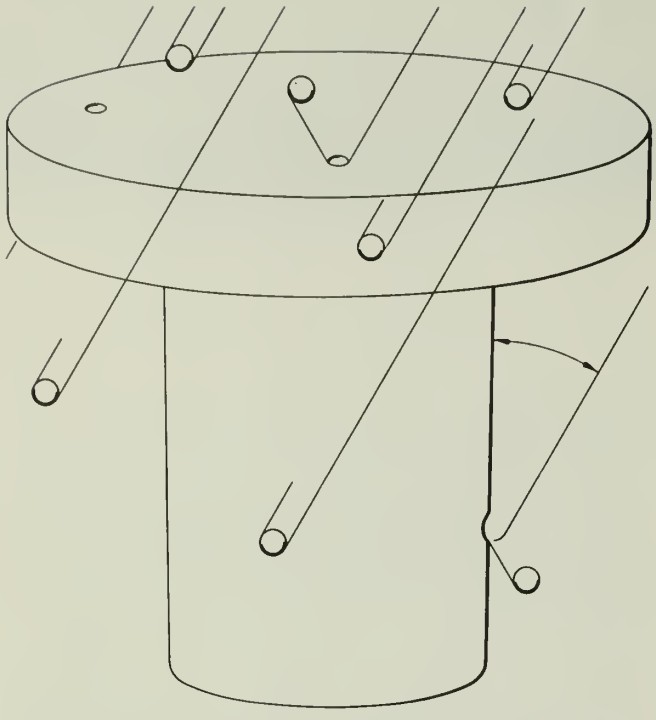
The day has passed when all a man needed was two sticks and dry weather to study fire; a University of Illinois chemical engineer, Assistant Professor R. A. Schmitz, is using a computer to simulate a flame and blow it out again. His idealized mathematical analysis involves equations too complex for convenient human solution, so he and his colleagues have given a computer the task of keeping track of the flame's varying chemical reaction and mass and energy flow.

Their special interest is combustion stability — finding out just how much the circumstances of a fire can be varied before the reaction becomes so unstable that it stops. The results of this new instability approach indicate that the researchers can predict with increased accuracy the exact conditions of flame extinction.

Among those interested in these conditions are designers and users of jet and rocket engines, chemical and petroleum processing equipment, and other hardware in which combustion occurs.

A related study examined the chemical reaction conditions near the front of a blunt body; similar conditions might exist near a space capsule during its reentry into the atmosphere. Again the computer simulated the blistering temperatures and complex interworkings of the reaction. An interesting result of the study was the computer's prediction of an oscillating reaction in which the temperature rises and falls, in a situation comparable to the flickering of a dying candle flame. Such a situation may not yet have occurred with any actual reentry vehicle, but it could impose serious overloads on a cooling system, not designed to compensate for its extraordinary temperatures — and perhaps even destroy it.

The next step in Schmitz' research will be a series of laboratory tests to substantiate the computer results and, particularly, to investigate the occurrence of the oscillating reaction. If the laboratory tests confirm the computer predictions, engineers may gain a more systematic, rational approach to the design of devices which use or withstand combustion, and a greater understanding of how combustion works. ◆



A hoilstane leaves its mork on this foam-plostic mushroom, developed for research headed by Stanley A. Changnon, o climatalogist for the Stote Woter Survey at the University af Illinais. Indentations on the device provide o record of the size, concentrotion, ond ongle of foll of hailstones at untended recording stations. From such data, the reseorchers hope ta be oble to modify ar prevent hailstorms ond reduce the domoge they couse.

KEEPING RAIN WET

A small rocket is blasted into the atmosphere from a collective farm in the Soviet Ukraine. Fifteen hundred miles to the southwest an Italian fruit grower launches his own miniature missile. A political crisis? No. This picture might fit farmers of the future at war with a common enemy — hail. They hope to use rockets to seed the clouds with silver iodide, causing moisture to condense and fall as rain before conditions develop which could turn the droplets into hail.

The techniques being advanced to eliminate or modify hailstorms in Europe have made American scientists aware of how little is known about hail activity in the United States. Before methods can be developed to deter this costly and damaging whim of nature, studies must be made to determine the norms of hail damage over a period of years within specified regions. Also the properties of the hailstones themselves must be analyzed so that techniques for combating the storms can be accurately evaluated.

Climatologist Stanley A. Changnon of the State Water Survey at the University of Illinois has been given a National Science Foundation grant to conduct such a study in East Central Illinois, a region representative of most of the Midwest. The study will be conducted over a two-year period within a hundred miles of Champaign-Urbana.

All data recorded on local hailstorms since 1900 will be gathered and analyzed; trends will then be tabulated and projected into the future. Changnon also hopes to prevail upon some two thousand farmers in the area to keep regular, detailed accounts of hail activity on their property during the six-month hail season starting next April. They will be asked to record not only the date and time of the storms, but also the size, frequency, and angle of fall of the hailstones themselves. Their findings will then be compared with the information obtained from radar echos, in order to evaluate the reliability of radar as a prognosticator of hail-bearing storms.

To supplement this effort, plans are being developed for a mechanical apparatus which would automatically record the force of impact, size, angle, and concentration of hailstones in sparsely populated areas. Such a device, now being designed in cooperation with the Department of General Engineering, would be equipped with an electrical timing mechanism which would indicate the date and duration of the storm. One model now being considered is simply a fourteen-inch polystyrene mushroom. The depth, concentration, and position of indentations resulting from hailstones falling on the head and stem of this apparatus would indicate a number of properties of the stones. If all goes as planned, the study should indicate the best means of assessing results from future hail modification programs. ◆

BENDING THE LANGUAGE BARRIER

An engineer's main job is the creation of hardware to meet current needs. But knowing what needs are imminent, who will use his product, and whether his idea is even feasible requires that the engineer base his designs on market research and other nontechnical knowledge, as well as on technological research.

An acceptable design must be preceded by a free flow of mutual information, in a mutually understood language, among engineering research, market research, product development, cost accounting, finance, manufacturing, equipment development, purchasing, and marketing personnel. Evaluation, analysis, data processing, and final decisions must be based on a multidisciplinary effort.

But bringing engineers together with accountants, sales managers, and manufacturers in a business situation can be difficult. To promote a free exchange of information, the University of Illinois Extension Division, in cooperation with the College of Engineering, is currently conducting special courses for practicing executives.

Under this program such executives as sales managers, manufacturing engineers, research directors, accountants, and purchasing coordinators from the same firm meet under the direction of a University faculty member and discuss the communications problems that exist among their departments. Jointly recognizable concepts of engineering, cost accounting, manufacturing, finance, and marketing are analyzed, and a mutually comprehensible term is applied to each concept for use within the corporation.

To further improve communications among the departments of a company, a College of Engineering motion picture, *Group Decisions in Industry,* is available for rental from the U of I Visual Aids Service, 704 South Sixth Street, Champaign, Illinois 61820.

Persons interested in detailed information about these Extension Division courses should contact Professor William F. Berkow, 8 Transportation Building. ◆

RESEARCH SUMMARIZED

The Summary of Engineering Research 1966, now available, is the ninth publication in a series which annually gives a complete description of the research conducted in the College of Engineering at the University of Illinois in Urbana. Over 600 projects are listed with sponsors, investigators, and the publications resulting from the research. The catalog is indexed for easy location of specific research areas. It may be purchased from the Engineering Publications Office at $5.00 per copy. ◆

SCHOLARS' SPECIAL

A special series of interdisciplinary Engineering Honors courses for undergraduates begun in September will be continued in the spring semester, according to J. O. Kopplin, chairman of the Engineering Honors Council at the University of Illinois. The courses are open to James Scholars in Engineering and other engineering students who secure the consent of the course instructor. These courses are offered by the College of Engineering to supplement the honors courses offered by the various engineering departments.

Currently the following courses are being offered: "The Engineer and Society," "The Engineer and His Profession," and "Introduction to Fortran Programming" and "Space Vehicle Design," offered as seminars. For the spring semester the first three of these courses will again be offered, along with "The Science of Engineering Materials." This new course will study the relationship between material structure and the various properties which account for many of the advances being made through the application of new materials.

These courses are designed to draw James Scholars from throughout the College together in a team study of interdisciplinary subjects of current interest. Guest lecturers from NASA and aerospace industries, as well as experts from the University faculty, have appeared before the honors classes. Further information about the courses can be obtained from Professor Kopplin at 359 Electrical Engineering Building. ◆

BUILD CONFERENCE PROCEEDINGS

The Proceedings of the BUILD Conference of the University of Illinois and the University of Colorado Senior Faculty Members of Civil Engineering, *The Transportation Option in the Civil Engineering Curriculum,* is available from the Engineering Publications Office for $2.00. ◆

POPULAR TECHNICAL REPORT SERIES AVAILABLE

The following series of technical reports, published by the University of Illinois Department of Civil Engineering, has been made available through the Engineering Documents Office:

Report #2. "Extensions of the Critical Path Method Through the Application of Integer Programming," by W. L. Meyer and L. R. Shaffer. $2.00.

Report #3. "An Application of the Theory of Queues to the Forecasting of Shovel Truck Fleet Productions," by J. B. O'Shea, G. N. Slutkin, and L. R. Shaffer. $2.50.

Report #4. "An Evaluation of Some Competitive Bid Strategy Models for Contractors," by B. J. Casey and L. R. Shaffer. $2.00.

Report #5. "The Resource Scheduling Problem in Construction," by J. D. Brand, W. L. Meyer, and L. R. Shaffer. $2.00.

Report #6. "Construction Costs CPM and the Digital Computer," by A. C. Alberga and L. R. Shaffer. $2.50.

Report #7. "COBESTCO Computer Based Estimating Technique for Contractors," by Peter Kramer and L. R. Shaffer. $2.00.

Report #8. "Staged Decision Theory Applied to the Limited Resource Problem," by J. J. Baker and L. R. Shaffer. $2.00.

The reports, widely used by construction companies and other contractors, are also available as a complete set for $12.00. Orders should be sent to the Engineering Documents Office, 112 Engineering Hall, University of Illinois, Urbana, Illinois 61801. ◆

NINTH SANITARY ENGINEERING CONFERENCE

Instrumentation, Control, and Automation for Water Supply and Wastewater Treatment Systems is the title of the Ninth Sanitary Engineering Conference to be held in Urbana, Illinois, on February 7 and 8, 1967. This Conference is planned for sanitary engineers in government, industry, and private practice, and water works managers and operators. The Division of Sanitary Engineering, Illinois Department of Public Health, and the University of Illinois Department of Civil Engineering are the joint sponsors. Further information may be obtained from John H. Austin, Associate Professor of Sanitary Engineering, 203 Engineering Hall, Urbana. ◆

PEOPLE AND PLACES

Duane H. Cooper, Associate Professor of Electrical Engineering and Physics at the University of Illinois Coordinated Science Laboratory, was awarded a fellow certificate at the convention of the Audio Engineering Society on October 13 in New York. The award recognized his work in the analysis of sound distortions in the playing of phonograph records.

President Johnson has appointed Professor **Edwin L. Goldwasser** of the University of Illinois Physics Department to the general advisory committee of the Atomic Energy Commission. The Committee advises AEC on scientific and technical matters.

Sanitary Engineering Professor **Richard S. Engelbrecht** has received the Harrison Prescott Eddy Award from the Water Pollution Control Federation. Recognition was also given to two former department members who worked with Engelbrecht in the treatment of industrial waste: Professor R. E. Speece, now at New Mexico State University, and C. V. Ramarao, now a consulting engineer at Ann Arbor, Michigan.

John E. Baerwald, Director of the Highway Traffic Safety Center and Professor of Traffic Engineering, has been named secretary-elect of the Institute of Traffic Engineers. The position was announced October 13 at the Institute's annual meeting.

Civil Engineering Professor **William A. Oliver** has announced his retirement after serving thirty-seven years on the Illinois faculty. The recipient of many awards, he will continue to direct the job placement service of the Department of Civil Engineering. He has also assumed the responsibility for coordinating the Department's publications.

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